U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Arborimus longicaudus

Common Name:

red tree vole

Lead region:

Region 1 (Pacific Region)

Information current as of:

03/25/2015

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

___ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status

___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species

___ Range is no longer a U.S. territory

___ Insufficient information exists on biological vulnerability and threats to support listing

___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"

___ Taxon believed to be extinct

___ Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 06/22/2007

90-Day Positive:10/28/2008

12 Month Positive:10/13/2011

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower listing priority numbers). During the past 12 months, the majority of our entire national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements; meeting statutory deadlines for petition findings or listing determinations; emergency listing evaluations and determinations; and essential litigation-related administrative and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of Progress on Revising the Lists, in the current CNOR which can be viewed on our Internet website (http://endangered.fws.gov/).

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Oregon
- **US Counties**: Benton, OR, Clatsop, OR, Columbia, OR, Douglas, OR, Lane, OR, Lincoln, OR, Multnomah, OR, Polk, OR, Tillamook, OR, Washington, OR, Yamhill, OR
- **Countries**:Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Oregon
- **US Counties**: Benton, OR, Clatsop, OR, Columbia, OR, Douglas, OR, Lane, OR, Lincoln, OR, Multnomah, OR, Polk, OR, Tillamook, OR, Washington, OR, Yamhill, OR
- **Countries**:Country information not available

Land Ownership:

The North Oregon Coast Distinct Population Segment (DPS) encompasses roughly 1.6 million hectares (ha) (3.8 million acres (ac)). Private lands make up 62 percent of the ownership, with a mix of individual and industrial forest owners.

State lands comprise 16 percent of the DPS. Although there are some scattered State parks located primarily along the coastal headlands, virtually all of the State ownership in the DPS is land managed by the Oregon Department of Forestry (ODF) in the Tillamook and Clatsop State Forests, as well as other scattered parcels of State forest land in the southern half of the DPS.

Federal lands make up 22 percent of the DPS. The Siuslaw National Forest comprises 41 percent of the Federal land within the DPS, and the Salem and Eugene Districts of the Bureau of Land Management (BLM) make up the remainder, along with a small portion of the Roseburg BLM District.

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Biological Information

Species Description:

Published literature on the red tree vole (Arborimus longicaudus) also includes work conducted on the closely related Sonoma tree vole (Arborimus pomo). Prior to 1991, these taxa were both considered a single species, red tree vole (Johnson and George 1991, entire). Where pertinent information is lacking or limited for the red tree vole, information on the Sonoma tree vole is presented because there have been no ecological or life-history differences noted for the two species (Smith et al. 2003, p. 187).

Tree voles are small, mouse-sized rodents that live in conifer forests and spend almost all of their time in the tree canopy (Fig. 1). Tree voles rarely come to the ground, and do so only to move briefly between trees. They are one of the few animals to persist on a diet of conifer needles, which is their principal food. When eating, tree voles strip away the resin ducts within conifer needles and eat the remaining portion; resin ducts contain terpenoid chemicals that make them unpalatable to most species. Red tree voles live singly (or with young, in the case of females) in nests made of vegetation and other materials. Swingle (2005, p. 2) summarized the sizes of red tree vole nests as ranging from very small ephemeral structures about the size of a grapefruit, to large old maternal nests that may be nearly as large as a bushel basket and completely encircle the trunk of the tree (Taylor 1915, p. 146; Howell 1926, pp. 43-47; Verts and Carraway 1998, p. 310). Nests of females tend to be larger than those of males. Males and females live separate lives once leaving the nest, only coming together to breed. Further details of the life-history characteristics of tree voles are presented below.

Tree voles are less than 20.9 centimeters (cm) (8.2 inches (in)) long and weigh up to 49 grams (g) (1.7 ounces (oz)) (Hayes 1996, p. 1; Verts and Carraway 1998, p. 301; Forsman 2010, pers. comm.). Pelage (fur) color ranges from brownish red to bright brownish-red or orange-red (Maser et al. 1981, p. 201). Though rare, cream-colored and melanistic (all black) forms of the red tree vole have been found (Swingle 2005, pp. 46, 82).

Red Tree Vole. Photo by Nick Hatch.

Taxonomy:

The taxonomic history of the red tree vole is confounded by descriptions of a putative subspecies, the dusky tree vole (A. l. silvicola). A description of red tree vole taxonomy can be found in Miller et al. (2010, pp. 64-65). The red tree vole was first described from a specimen collected in Coos County, Oregon (True 1890, pp. 303-304), and originally placed in the genus Phenacomys. The dusky tree vole was first described from a dead specimen found in Tillamook County and originally classified as a distinct species, P. silvicolus (Howell 1921, entire), later renamed P. silvicola (Miller 1924, p. 400). Taylor (1915, p. 156) established the subgenus Arborimus for tree voles, which Johnson (1968, p. 27; 1973, p. 243) later proposed elevating to full generic rank, although this genus has not been universally adopted (e.g., Verts and Carraway 1998, pp. 309-311). For the purpose of this finding, we use the generic classification, Arborimus.

Johnson (1968, p. 27) concluded that analysis of blood proteins and hemoglobin from dusky and red tree voles "[...] suggested combining the named forms of Arborimus into a single species [...]." Hall (1981, p. 788) cited Johnson (1968, p. 27) as suggesting a subspecific relationship of the two taxa, and others have cited Johnson as well in supporting the classification of the dusky tree vole as a subspecies (e.g., Maser and Storm 1970, p. 64; Johnson and George 1991, p. 1). However, based on a lack of detectable genetic differences and a lack of consistently verifiable morphological differences between dusky and red tree voles, Bellinger et al. (2005, p. 207) suggested subspecific status of the dusky tree vole may not be warranted.

Miller et al. (2006a, entire) analyzed mitochondrial DNA sequences from red tree voles throughout their range in Oregon. The authors found significant genetic discontinuities based on unique haplotypes that result in three genetically distinct groupings of red tree voles. Although one of these groupings generally encompassed the geographical range described for the dusky tree vole, the authors did not comment on the taxonomic status of the subspecies. Subsequent conversations with the geneticists who authored this paper indicated that the genetic differences described in Miller et al. (2006a, entire) were substantial enough to potentially warrant taxonomically classifying the three genetically distinct groups as separate subspecies if there were corresponding differences in other traits, such as behavior or morphology, to provide additional support (Miller and Haig 2009, pers. comm.). Review of external morphological characters by Miller et al. (2010, entire) did not distinguish dusky tree voles from red tree voles, but the authors noted that additional analysis of other physical characteristics (e.g., fur color) would be required to better determine the dusky tree voles taxonomic status.

In the 12-month finding for the red tree vole, we assessed the subspecies classification for the dusky tree vole (76 FR 63720, October 13, 2011, pp. 63726-63728). We evaluated all the available information to determine whether the evidence points to a consistent separation of the putative dusky tree voles from the remaining population of red tree voles. We looked at multiple characteristics (geographical range, blood proteins, genetics, morphology, and behavior) to determine if there was a clear and consistent separation of the putative dusky tree vole subspecies from the remaining red tree vole population, indicative of a likely valid subspecies. It was our conclusion that there was insufficient evidence to indicate that the dusky tree vole is a distinct subspecies of the red tree vole. Although the dusky tree vole was recognized as a subspecies in Wilson and Reeder's Mammal Species of the World (2005, pp. 962-963), we note that this reference did not recognize, nor was published prior to, the work of Bellinger et al. (2005, entire) and Miller et al. (2006a, entire; 2010 entire). Subsequent to the publication of some of these latter works, the Oregon Natural Heritage Information Center ceased recognition of the dusky tree vole as a subspecies (ORNHIC 2007, p. 17), as did the U.S. Forest Service and BLM Survey and

Manage program (USDA and USDI 2007, p. 289). Finally, the dusky tree vole is not recognized as a valid subspecies of the red tree vole in the Integrated Taxonomic Information System (ITIS 2011). Therefore, based on the best available scientific and commercial data, as described above, we have concluded that the dusky tree vole is not a valid subspecies, and therefore is not eligible for listing as such under the Act. The rest of this assessment considers whether the red tree vole species continues to warrant listing under the Act.

Habitat/Life History:

Home Range and Dispersal

The only published data on home range sizes and dispersal come from red tree voles radio-collared in the southern Coast Range and southern Cascades of Douglas County in southwestern Oregon (Swingle 2005, pp. 51-63, 84-89; Swingle and Forsman 2009, entire). Of 45 radio-collared red tree voles, 18 had home ranges consisting of their nest tree and a few adjacent trees, whereas the remainder occupied up to 6 different nests spaced up to 162 meters (m) (532 feet (ft)) apart in different trees (Swingle and Forsman 2009, p. 277). Mean and median home ranges were 0.17 ha (0.43 ac) and 0.08 ha (0.19 ac), respectively (Swingle and Forsman 2009, p. 278). Home range sizes did not differ among gender, age, or among voles occurring in young (22 to 55 years old) versus old (110 to 260 years old) forests (Swingle and Forsman 2009, pp. 277-279). An unpublished study conducted by Brian Biswell and Chuck Meslow found mean male home ranges of 0.35 ha (0.86 ac) and mean female home ranges of 0.15 ha (0.37 ac) (Biswell and Meslow, unpublished data referenced in USDA and USDI 2000b, p. 8). Dispersal distances of nine subadults ranged from 3 to 75 m (10 to 246 ft) (Swingle 2005, p. 63). The longest known straight-line dispersal distance was for a subadult male who traveled 340 m (1,115 ft) over the course of 40 days (Biswell and Meslow, unpublished data referenced in USDA and USDI 2000b, p. 8).

Habitat

Red tree voles are found exclusively in conifer forests or in mixed forests of conifers and hardwoods (Hayes 1996, p. 3). Throughout most of their range, they are principally associated with Douglas-fir (Pseudotsuga menziesii) for foraging and nesting (Jewett 1920, p. 165; Bailey 1936, p. 195). However, their nests have also been documented in Sitka spruce (Picea sitchensis) (Jewett 1920, p. 165), grand fir (Abies grandis), western hemlock (Tsuga heterophylla), Pacific yew (Taxus brevifolia), and non-conifers such as bigleaf maple (Acer macrophyllum) and golden chinquapin (Castanopsis chrysophylla) (Swingle 2005, p. 31). Hardwoods are generally not recognized as an important habitat component (USDA and USDI 2002, p. 1). Tree vole nests are located in the forest canopy and are constructed from twigs and resin ducts discarded from feeding, as well as fecal pellets, lichens, dead twigs, and conifer needles (Howell 1926, p. 46; Clifton 1960, pp. 53-60; Maser 1966, pp. 94-96; Gillesberg and Carey 1991, p. 785; Forsman et al. 2009a, p. 266). Single large branches, mistletoe brooms, and re-sprouted branch clusters serve as stable foundations for vole nests in larger trees, while whorls of branches or forked tops can provide secure sites for nesting in smaller trees as well (USDA and USDI 2000b, p. 7). On the occasions when tree voles nest in non-conifers or snags, they are virtually always in trees that have limbs interconnected with adjacent live conifers where the voles can obtain food (Maser 1966, p. 78; Swingle 2005, p. 31). Within the northern Oregon Coast Range, primarily in the Sitka spruce plant series (see Distinct Population Segment for plant series description), tree vole diet and nest tree species selection favors western hemlock and Sitka spruce (Walker 1930, pp. 233-234; Forsman et al. 2008, Table 2; Forsman and Swingle 2009, pers. comm.; Maser 2009, pers. comm.; Price et al. 2015, pp. 43, 45), although some vole nests have been found in Douglas-fir in this plant series (Howell 1921, p. 99; Jewett 1930, pp. 81-83; Forsman and Swingle 2009, pers. comm.; Price et al. 2015, pp. 43).

Based on their study of small mammal habitat associations in the Oregon Coast Range, Martin and McComb (2002, p. 262) considered red tree voles to be habitat specialists. In that study of forests of different patch types, red tree voles selected conifer large sawtimber patch types and landscapes where fragmentation of mature conifer forest was minimized (Martin and McComb 2002, pp. 259, 261, 262). The vegetation classification scheme used by Martin and McComb (2002, p. 257) defines the conifer large sawtimber patch type as forest patches with greater than 70 percent conifer composition, more than 20 percent canopy cover, and mean diameter at breast height (dbh) greater than 53.3 cm (21 in); it should be noted that in other studies where researchers actually measured the canopy cover of stands used by red tree voles, the minimum canopy cover requirements of red tree voles were much higher, on the order of 53 to 66 percent (e.g., Swingle 2005, p. 39). Red tree voles were most abundant in contiguous mature conifer forest (unfragmented landscapes), and were negatively affected by increasing patch densities at the landscape scale (Martin and McComb 2002, p. 262).

Although red and Sonoma tree voles occur and nest in young forests (Jewett 1920, p. 165; Brown 1964, p. 647; Maser 1966, p. 40; Corn and Bury 1986, p. 404; Thompson and Diller 2002, entire; Swingle and Forsman 2009, p. 277; Price et al. 2005, p. 45; Forsman et al. undated, p. 4), most comparisons of relative abundance from pitfall trapping and nest presence data show increased occurrence in older forests throughout the ranges of these species (Corn and Bury 1986, p. 404; Corn and Bury 1991, pp. 251-252; Ruggiero et al. 1991, p. 460; Meiselman and Doyle 1996, p. 38; Gomez and Anthony 1998, p. 296; Martin and McComb 2002, p. 261; Jones 2003, p. 29; Dunk and Hawley 2009, entire). Furthermore, where voles were found in younger stands in coastal Oregon, the vast majority of stands examined were not occupied by tree voles (Price et al. 2015, pp. 45-46; Forsman et al. undated, p. 5). The occurrence of active nests in remnant older trees in younger stands indicates the importance of legacy structural characteristics (USDA and USDI 2002, p. 1). Although the bulk of the evidence points to forests with late-successional characteristics as important to the red tree vole, we lack specific data on the minimum size of trees or stands required to sustain populations of the red tree vole over the long term.

There is no single description of red tree vole habitat and a wide variety of terms have been used to describe the older forest stands the tree voles tend to select (e.g., late-successional, old-growth, large conifer, mature, structurally complex). In this analysis, we use these terms as they appear in the cited literature or as specific ages are referenced. Otherwise, we use the term older forest when collectively referring to these stand conditions. In using the term older forest, we are not implying a specific stand age that represents tree vole habitat. Rather, we use the term to represent the assemblage of old and large trees, multiple canopy layers, snags and other decay elements, understory development and biologically complex structure and composition often found in forests selected by tree voles.

The most extensive and intensive analysis of red tree vole habitat associations on Federal lands throughout the voles range found a strong association between tree vole nest presence and late-successional and old-growth forest conditions (forests over 80 years old), with optimal red tree vole habitat being especially rare (Dunk and Hawley 2009, p. 632). Throughout their range on Federal land, the probability of red tree vole nest presence (Po) in the highest quality habitat (forest exhibiting late-successional structural characteristics) was 7 times more than expected based on the proportional availability of that habitat, whereas in lowest quality, early-seral forest conditions, Po was 7.6 times less than expected based on availability (Dunk and Hawley 2009, p. 632). In other words, red tree voles demonstrated strong selection for nesting in stands with older forest characteristics, even though that forest type was relatively rare across the landscape. Conversely, tree voles avoided nesting in younger stand types that were much more common across the landscape.

Trees containing tree vole nests are significantly larger in diameter and height than those without nests (Gillesberg and Carey 1991, p. 785; Meiselman and Doyle 1996, p. 36 for the Sonoma tree vole). Other forest conditions associated with red tree vole habitat include the number of large trees and variety of tree size distribution (Dunk and Hawley 2009, p. 632). Carey (1991, p. 8) suggested that tree voles seem especially well-suited to the stable conditions of old-growth Douglas-fir forests (multi-layered stands over 200 years old, with decay elements). Old-growth trees may be optimum tree vole habitat because primary production is high and needles are concentrated, providing maximum food availability (Carey 1991, p. 8). In addition, old-growth canopy buffers weather changes and has high water-holding capacity, providing fresh foliage and a water source (Gillesberg and Carey 1991, pp. 786-787), as well as numerous cavities and large limbs that provide stable nest substrates.

As noted above, tree voles can be found in younger forests, sometimes at fairly high densities (Howell 1926, pp. 41-45: Maser 1966, pp. 216-217; Thompson and Diller 2002, p. 95; Price et al. 2015, pp. 43, 45; Forsman et al. undated, p. 4). It is not understood how younger forests influence the abundance, persistence, or dispersal of red tree voles. Carey (1991, p. 34) suggested younger forests were population sinks for red tree voles. Based on surveys in young forests (22 to 55 years old) and observations of radio-collared tree voles, Swingle (2005, pp. 78, 94) and Swingle and Forsman (2009, pp. 283-284) concluded that some young forests may be important habitat for tree voles, particularly in landscapes where old forests have largely been eliminated or currently exist in isolated patches. However, Swingle (2005, pp. 78, 94) cautioned against using the occasional presence of tree voles in young forests to refute the importance of old forest habitats to tree voles. Young forest stands may serve as interim habitat for tree voles and may provide connectivity between remnant patches of older forest, but whether younger forests are capable of supporting viable populations of tree voles over the long term is uncertain. Furthermore, Price et al. (2015, pp. 45-46) concluded that even though a limited number of nests were found in younger stands in their study (and even then, only where adjacent to older forest stands), the vast majority of young stands that were examined had no evidence of tree vole nests. The limited evidence available suggests that where tree voles do occupy younger forest stands, it may be relatively short-lived (Diller 2010, pers. comm.) or intermittent (Hopkins 2010, pers. comm.).

After weighing all of the best available information, we conclude that although red tree voles may use younger forest types to some degree, the preponderance of evidence suggests red tree voles demonstrate strong selection for forests with older forest conditions, as well as contiguous forest conditions. Whether tree voles can potentially persist in younger forests over the long term is unknown (USDA and USDI 2007, p. 291). However, although the data are limited, the available evidence suggests that red tree voles likely do not maintain long-term or consistent populations in younger stands (Diller 2010, pers. comm.; Hopkins 2010, pers. comm.). There is a relatively large body of evidence showing that red tree voles exhibit strong selection for areas of contiguous habitat displaying characteristics of older, mature forests (Corn and Bury 1986, p. 404; Corn and Bury 1991, pp. 251-252; Ruggiero et al. 1991, p. 460; Meiselman and Doyle 1996, p. 38; Gomez and Anthony 1998, p. 296; Martin and McComb 2002, p. 261; Jones 2003, p. 29; Dunk and Hawley 2009, entire). We therefore further conclude that unfragmented forests with late-successional characteristics are most likely to provide for the long-term persistence of the species, and in this finding we consider these older forest types as representative of high-quality habitat for the red tree vole.

Tree voles may tolerate some forest fragmentation, but the point at which forest gaps become large enough to impede their movements or successful dispersal is not known. Howell (1926, p. 40) suggested that considerable expanses of land without suitable trees are a barrier to tree vole movements. As noted earlier, known dispersal distances for red tree voles are quite short, generally ranging from 3 to 75 m (10 to 246 ft) (Swingle 2005, p. 63), with 340 m (1,115 ft) being the longest known dispersal distance (Biswell and Meslow, unpublished data referenced in USDA and USDI 2000b, p. 8). This suggests that relatively small distances, roughly less than 366 m (1,200 ft) between forest patches, may serve as effective barriers to dispersal or recolonization for red tree voles. Radio-collared tree voles crossed logging roads, first-order streams, and canopy gaps up to 25 m (82 ft) wide (Biswell and Meslow, unpublished data referenced in USDA and USDI 2000b, p. 8; Swingle and Forsman 2009, p. 283). Some of these crossings occurred on multiple occasions by a single vole. This suggests that small forest gaps (Swingle 2005, p. 79) may not greatly impair tree vole movement, but increasing gap size may be expected to limit tree vole movement. Although tree voles may be capable of these movements, Swingle (2005, p. 79) suggested that the necessity of descending to the ground to cross openings may reduce survival. There are three records of red tree voles captured in clearcuts (Borrecco 1973, pp. 34, 36; Corn and Bury 1986, pp. 404-405; Verts and Carraway 1998, p. 310), in one case over 200 m (656 ft) from the forest edge. In two of these instances, the authors suggested the individuals were most likely in the act of dispersing.

In summary, based on our evaluation of the best scientific and commercial data available, as detailed above, for the purposes of this finding we consider older forests with late-successional characteristics to represent high-quality habitat for red tree voles, and younger forests in early-seral condition to represent low-quality, transitional habitat for red tree voles. In addition, we consider it likely that younger forests only play a role as interim, low-quality habitat for red tree voles if they occur in association with older forest patches or remnants.

Reproduction

Red tree vole litter sizes are among the smallest compared to other rodents of the same subfamily, averaging 2.9 young per litter (range 1 to 4) (Maser et al. 1981, p. 205; Verts and Carraway 1998, p. 310). Clifton (1960, pp. 119-120) reported that captive tree voles became sexually mature at 2.5 to 3.0 months of age. Females breed throughout the year, with most reproduction occurring between February and September (Swingle 2005, p. 71). Red tree voles are capable of breeding and becoming pregnant immediately after a litter is born (Clifton 1960, p. 130; Hamilton 1962, pp. 492-495; Brown 1964, pp. 647-648), resulting in the potential for females to have two litters of differently aged young in their nests (Swingle 2005, p. 71; Forsman et al. 2009a, p. 270). Captive tree voles may have litters just over a month apart (Clifton 1960, p. 130). Forsman et al. (2009a, p. 270) observed two female voles in the wild that produced litters at 30 to 35 day intervals. Young tree voles develop more slowly than similar-sized rodents of the same subfamily (Howell 1926, pp. 49-50; Maser et al. 1981, p. 205), first exiting the nest at 30 to 35 days old, and not dispersing until they are 47 to 60 days old (Swingle 2005, p. 63; Forsman et al. 2009a, pp. 268-269).

Diet

Tree voles are unique in that they feed exclusively on conifer needles and the tender bark of twigs that they harvest from conifers. In most of their range, they feed primarily on Douglas-fir (Howell 1926, p. 52; Benson and Borell 1931, p. 230; Maser et al. 1981, p. 205). In portions of the northern coastal counties of Oregon (Lincoln, Tillamook, and Clatsop), tree voles also consume needles from western hemlock and Sitka spruce, and in some parts of their range they feed on grand fir, bishop pine (Pinus muricata), and introduced Monterrey pine (P. radiata) (Jewett 1920, p. 166; Howell 1926, pp. 52-53; Walker 1930, p. 234; Wooster and Town 2002, pp. 182-183; Forsman and Swingle 2009, pers. comm.; Swingle 2010, pers. comm.). Conifer needles contain filamentous resin ducts that are filled with terpenoids, chemicals that serve as defensive mechanisms for trees by making the leaves unpalatable. Tree voles have adapted to their diet of conifer needles by stripping away these resin ducts and eating the more palatable portion of the needle (Benson and Borell 1931, pp. 228-230; Perry 1994, pp. 453-454; Maser 1998, pp. 220-221; Kelsey et al. 2009, entire). Resin ducts typically run the length of the needle, but may be located in different portions of the needle, depending on the tree species; this forces the tree vole to engage in different eating behaviors, depending on the tree species on which they forage. As an example, the resin ducts in Douglas-fir needles are located along the outer edges of the needle, so tree voles remove the outside edge and consume the remaining middle portion of the needle. Conversely, the resin ducts of western hemlock are located away from the outside edges along the midline of the needle. Thus, voles foraging on hemlock needles will consume the outer edge of the needle and discard the center (Clifton 1960, pp. 35-45; Forsman and Swingle 2009, pers. comm.; Kelsey et al. 2009, entire; Maser 2009, pers. comm.).

Within the Sitka spruce plant series of the northern Oregon Coast Range of Oregon, tree voles appear to prefer, and perhaps require, a diet of western hemlock and Sitka spruce needles (Walker 1930, p. 234; Forsman and Swingle 2009, pers. comm.; Maser 2009, pers. comm.;). Voles in the Sitka spruce plant series rarely forage on Douglas-fir, even where it is available; foraging on Douglas-fir only becomes more evident where the Sitka spruce plant series transitions into the adjacent western hemlock series (Forsman and Swingle 2009, pers. comm.; Forsman and Swingle 2009, unpublished data). Maser (2009, pers. comm.) observed that tree voles adapted to a diet of western hemlock starved to death in captivity because they would not eat the Douglas-fir needles they were offered. Because the resin ducts of western hemlock, Sitka spruce, and Douglas-fir needles are in different locations on the needle, their removal requires a different behavior depending on which species is being eaten (Clifton 1960, pp. 35-49; Kelsey et al. 2009, entire). Maser (2009, pers. comm.) suspected that voles raised in stands of western hemlock never learned the required behavior for eating Douglas-fir, although Walker (1930, p. 234) observed a captive vole raised on hemlock needles that preferred hemlock but would eat fir or spruce in the absence of hemlock. Conversely, voles taken from Douglas-fir stands have been observed to eat both Douglas-fir and western hemlock in captivity (Clifton 1960, p. 44; Maser 2009, pers. comm.), although voles appear to be reluctant to switch between tree species (Walker 1930, p. 234; Forsman 2010, pers. comm.).

Tree voles were suspected of obtaining water from their food and by licking it from tree foliage (Clifton 1960, p. 49; Maser 1966, p. 148; Maser et al. 1981, p. 205; Carey 1996, p. 75). In keeping captive Sonoma tree voles, Hamilton (1962, p. 503) noted that it was important to keep leaves upon which they fed moist, otherwise the voles would lose weight and die. This led to the conclusion by some that the availability of free water in the form of rain or dew may limit the distribution of tree voles to relatively humid forests in western Oregon and California (e.g., Howell 1926, p. 40; Hamilton 1962, p. 503). However, Forsman and Price (2011, p. 116) found that captive voles fed a diet of fresh conifer needles needed little access to free water, consuming much lower amounts of water than that reported for most other species of voles; furthermore, red tree voles could obtain almost all of their water from the needles, which were low in caloric value but high in water content.

Mortality

In the only quantitative study conducted to date, Swingle et al. (2010, p. 258) found that weasels (Mustela spp.) were the primary predators of red tree voles. However, many other animals feed on tree voles, including ringtails (Bassariscus astutus) (Alexander et al. 1994, p. 97), fisher (Pekania pennanti) (Golightly et al. 2006, p. 17), northern spotted owls (Strix occidentalis caurina) (Forsman et al., 1984, p. 40), barred owls (Strix varia) (Wiens 2012, p. 57), and a variety of other nocturnal and diurnal raptors (Miller 1933, entire; Maser 1965a, entire; Maser 1965b, entire; Forsman and Maser 1970, entire; Reynolds 1970, entire; Graham and Mires 2005, entire). Other documented predators include the Steller’s jay (Cyanocitta stelleri) (Howell 1926, p. 60), gopher snakes (Pituophis catenifer) (Swingle et al. 2010, p. 258), domestic dogs (Canis familiaris) (Swingle et al. 2010, p. 258), and house cats (Felis catus) (Swingle 2005, pp. 90-91). In addition, Maser (1966, p. 164) found tree vole nests that had been torn apart and inferred the destruction was likely caused by northern flying squirrels (Glaucomys sabrinus), raccoons (Procyon lotor), western gray squirrels

(Sciurus griseus), or Douglas squirrels (Tamiasciurus douglasii), apparently in search of young voles. Forsman (2010, pers. comm.) recorded video footage of northern flying squirrels, western gray squirrels, and Douglas squirrels chasing tree voles or tearing into tree vole nests in what appeared to be attempts to capture voles (see also Swingle et al. 2010, p. 261).

Swingle et al. (2010, p. 259) estimated annual survival of radio-collared tree voles to be 15 percent. Little is known about the vulnerability of red tree voles to predators in different habitats. Swingle (2005, pp. 64, 90) found that of 25 documented cases of predation on radio-collared voles, most occurred in young (22 to 55 years old) forests (Forsman and Swingle 2009, pers. comm.). Predation by weasels, which accounted for 60 percent of the predation events, occurred only in young forests, and 80 percent of the weasel predation was on female voles; however, the majority of the tree voles radio-collared in the study were females in young forests, so forest age and vole gender explained little of the variation in the data (Forsman 2010, pers. comm.; Swingle 2010, pers. comm.). Although there was no statistical difference in predation rates among forest ages and vole gender, Swingle et al. (2010, p. 260) suspected weasel predation on tree voles may be inversely proportional to nest height. Tree vole nests tend to be found in the lower portion of the tree crown (Gillesburg and Carey 1991, pp. 785-786; Swingle 2005, pp. 29-30), and tree vole nests tend to be higher above the ground in older stands or larger trees than in younger stands or smaller trees (Zentner 1966, pp. 18-20; Vrieze 1980, pp. 18, 32-33; Meiselman and Doyle 1996, p. 38; Swingle 2005, pp. 29-30). Thus, tree voles could be more prone to predation in shorter trees that comprise younger stands where the height of nests above the ground is limited. Swingle et al. (2010, p. 261) also suggested that female tree voles may be more susceptible to predation than males because they occupy larger, more conspicuous nests and they spend more time outside the nest collecting food for their young. Other mortality sources include disease, old age, storms, forest fires, and logging (Maser et al. 1981, p. 206). Carey (1991, p. 8) suggested that forest fires and logging are far more important mortality factors than predation in limiting vole abundance.

Historical Range/Distribution:

Although past observations of tree voles are useful for assessing the historical range of the species, they may also be biased because collectors did not sample randomly. Thus, historical locations of tree voles tend to occur in clusters where a few collectors spent a lot of time searching for the species. Until extensive surveys were conducted by the Forest Service and BLM as part of the Survey and Manage program adopted in 1994 under the Northwest Forest Plan (NWFP), much of the range of the red tree vole had never been searched. Thus, the lack of historical documentation of tree vole presence cannot be interpreted to mean that tree voles had limited populations or were historically absent from an area, especially if that area formerly provided suitable forest habitat for tree voles and was contiguous with known occupied areas. Surveys by naturalists in the late 1800s and early 1900s were more of an inventory to find new species and to determine species presence as opposed to determining abundance and distribution of a particular species (Jobanek 1988, p. 370). Only portions of Oregon were surveyed, and coverage was cursory and localized. Given the arboreal existence of the red tree vole and difficulty of finding and observing them, few specimens were collected or observed until more was understood about their life history (Bailey 1936, p. 195; Jobanek 1988, pp. 380-381). Many nests were simply inaccessible to early naturalists. Nests were often high up in big trees, many of which were too large to climb without the benefit of climbing equipment, or the trees lacked enough branches on the lower bole to readily free-climb (e.g., Jobanek 1988, p. 391). Howell (1921, p. 99) noted that there was little hope for finding tree voles in virgin timber because of the large trees and the abundant moss that might conceal a score of hidden nests. Vernon Bailey, Chief Naturalist of the U.S. Bureau of Biological Survey, considered the red tree vole to be abundant in the wild yet rare in museum collections because of the difficulty in collecting them (Jobanek 1988, p. 382). Murray Johnson, the most prolific early collector of tree voles, spent most of his time searching in young forests because he could not climb big trees (Forsman 2010, pers. comm.).

Red tree voles are found on both the eastern and western slopes of the Oregon Coast Range. Although there are no records of red tree voles in Clatsop County north of Saddle Mountain or in Columbia County, it is possible that they occurred there as well given the presence of historical habitat (see Range and Distribution). There is a gap in the distribution of tree vole specimens and nests south of Saddle Mountain State Park in south-central Clatsop County, through the eastern two-thirds of Tillamook County south to the town of Tillamook (Forsman et al. 2009b, p. 229). There are no historical records of voles collected in this area, but there is also no evidence that early naturalists searched this area for tree voles. This gap in the current range corresponds roughly with the area of the Tillamook burn, a stand-replacing fire that burned over 121,400 ha (300,000 ac) in 1933 (Pyne 1982, pp. 330-331). This area reburned in three successive fires over the next 18 years, for a combined total burn area of 141,650 ha (350,000 ac) (Pyne 1982, pp. 330-331). It is reasonable to conclude that voles were present in this area prior to the fire, considering that much of the burned area contained older forest similar to forests occupied by tree voles in areas adjacent to the burn (Price et al. 2015, pp. 43, 45).

Descriptions of historical search efforts for red and Sonoma tree voles indicate that once the species behavior and life history were understood, searches for voles were more efficient and successful. Observers typically noted the patchy distribution of voles, and once they found voles, they tended to readily find multiple nests and voles in the same area (Taylor 1915, pp. 140-141; Howell 1926, pp. 42-43; Clifton 1960, pp. 24-30; Maser 1966, pp. 170, 216-217; Maser 2009, pers. comm.; Forsman and Swingle 2010, p. 104). For example, Clifton (1960, pp. 24-30) averaged one day searching for every red tree vole colony found near Newberg, Oregon, and Howell described more than 50 Sonoma tree voles being collected over two days near Carlotta, California in 1913 (Howell 1926, p. 43).

Current Range Distribution:

Tree voles are endemic to the humid, coniferous forests of western Oregon and northwestern California (Maser 1966, p. 7). The red tree vole occurs in western Oregon from below the crest of the Cascade Range to the Pacific coast (Hayes 1996, p. 2; Verts and Carraway 1998, pp. 309-310), with a geographic range covering approximately 6.6 million ha (16.3 million ac) across multiple ownerships (USDA and USDI 2007, p. 287) (Figure 1).

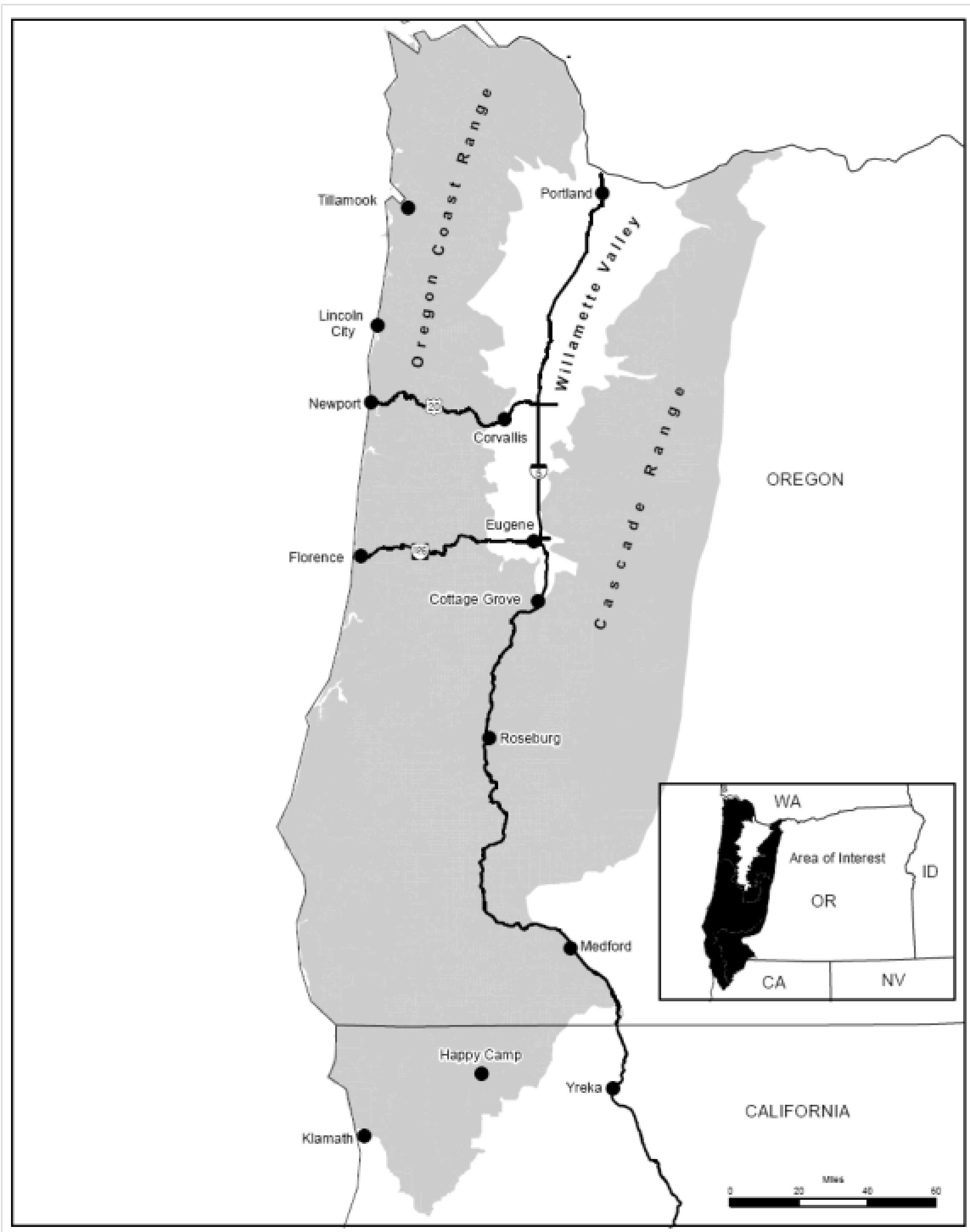

Figure 1. Range of the red tree vole.

The southern boundary of the range of the red tree vole borders the range of the Sonoma tree vole, which Johnson and George (1991, p. 12) classified as a separate species from the red tree vole. Johnson and George (1991, pp. 11-12) suggested the break between the ranges of these two species was the Klamath Mountains along the Oregon-California border. Murray (1995, p. 26) considered the boundary between the two species to be the Klamath River in northwestern California. This is supported by mitochondrial DNA analyses identifying tree voles in northwestern California (Del Norte County) as Arborimus longicaudus (Blois and Arbogast 2006, pp. 956, 958).

The red tree vole has not been found north of the Columbia River (Verts and Carraway 1998, p. 309), but the actual northern limit of its historical distribution in northwestern Oregon is unclear. Within the Oregon Coast Range, the northernmost tree vole collection site was in the vicinity of Saddle Mountain in central Clatsop County (Verts and Carraway 1998, pp. 310, 546; Forsman and Swingle 2009, pers. comm.). Although no tree voles have been detected in recent search efforts in northern Clatsop and Columbia counties (Forsman and Swingle 2009, unpublished data), the area historically had extensive forests with large Douglas-fir and western hemlock trees conducive to tree vole habitat (Robbins 1997, pp. 205-206). The Columbia River was considered Oregon's most productive logging center in the late 1800s (Robbins 1997, p. 220), and it is likely that virtually all of the suitable tree vole habitat in Clatsop, Columbia, and Washington counties was removed before tree vole occurrence could be recorded. Therefore, we believe it is reasonable to assume that tree voles were present in this part of Oregon prior to the late 1800s and early 1900s when these old forests were clear-cut or burned (Price et al. 2015, pp. 43, 45). Although tree voles appear to be largely absent from this portion of the state (Price et al. 2015, p. 45), they may be overlooked if they are sparsely distributed or few in number.

Recent surveys on the Tillamook and Clatsop State Forests, in Tillamook and Clatsop counties, yielded 35 tree vole nests, but 29 were not occupied (Price et al. 2015, p. 43). All nests were within or adjacent to older forest stands and located on the western edge of the Tillamook State Forest, outside of the areas that burned during the Tillamook fires. The surveys suggest that tree voles are largely absent from most of the Clatsop and Tillamook State Forests except for small isolated populations in relict forests that were not burned or harvested in the early to mid-1900s (Price et al. 2015, pp. 43, 45).

Farther east, the red tree vole occurs in the Columbia River Gorge from Wahkenna Creek to Seneca Fouts State Park, 6 kilometers (km) (4 miles (mi)) west of Hood River (Forsman et al. 2009b, p. 230). The red tree vole range had been described as west of the crest of the Cascade Range in Oregon (Corn and Bury 1986, p. 405). However, recent surveys have also found them just east of the Cascade Range crest, in the headwaters of the Lake Branch of Hood River, 30 km (19 mi) southwest of the town of Hood River (Forsman et al. 2009b, p. 227).

Surveys conducted for red tree voles by the Forest Service and the BLM as part of the Survey and Manage program under the NWFP have provided additional information on the distribution of the red tree vole (USDA and USDI 2007, p. 289). These surveys indicate red tree voles are uncommon and sparsely distributed in much of the northern Coast Range and northern Cascade Range of Oregon. Forsman et al. (2004, p. 300) reached the same conclusion based on remains of red tree voles in pellets of northern spotted owls, although data were sparse from the northern Oregon Coast Range compared to the rest of the red tree vole range. Based on these surveys and data from owl pellets, the eastern limit of red tree vole distribution in southwestern Oregon appears to include forested areas in Josephine County and a narrow band along the western and northern edges of Jackson County (Forsman et al. 2004, pp. 297-298; USDA and USDI 2007, p. 289).

Red tree voles are generally restricted to lower elevation coniferous forests, although there are a few records of this species above 1,300 m (4,265 ft) (Manning and Maguire 1999, entire; Forsman et al. 2004, p. 300). Hamilton (1962, p. 503) suggested red tree voles may be limited to lower elevations because their nests do not provide adequate insulation during winter. Because tree voles are active throughout the year, it is also possible they are absent from high-elevation areas because they find it difficult to forage on limbs covered with snow and ice during winter (Forsman et al. 2004, p. 300).

Population Estimates/Status:

Because of its arboreal existence and difficulty to observe and capture, little is known about the past and current population sizes of red tree voles. It is difficult to accurately estimate the size of a local tree vole population, let alone the population of the entire species (Howell 1926, p. 56; Blois and Arbogast 2006, p. 958). Estimates indicate that observers using ground-based survey methods may only see approximately half of the nests, with a bias towards observing more nests in younger forests than in older forests due to the greater visibility (Howell 1926, p. 45; Swingle 2005, pp. 78, 80-81; Swingle and Forsman 2009, p. 284). While nests can be counted and assessments have been made of the activity status of the nests, translating nest counts to numbers of voles does not yield good population estimates because some nests will be missed, some individuals occupy multiple nests, and determining whether nests are actively occupied is not possible without climbing to the nests and dissecting or probing them for voles (Swingle and Forsman 2009, p. 284). Using the presence or absence of green resin ducts and cuttings to determine the activity status of nests, which formerly had been a common method used in tree vole surveys, is now known to be unreliable for assessing actual nest occupancy by voles because the resin ducts can retain a fresh appearance for long periods of time if stored in the nest or out of sunlight, resulting in potential overestimates of active nest occupancy (USDA and USDI 2007, p. 290).

Although historical observations of tree voles are useful for assessing the range of the species, they may also be biased because collectors did not sample randomly. Thus, historical locations of tree voles tend to occur in clusters where a few collectors spent a lot of time searching for them. Until extensive surveys were conducted by the Forest Service and BLM as part of the Survey and Manage program adopted in 1994 under the NWFP, much of the range of the red tree vole had never been searched. The lack of historical documentation of tree vole presence thus cannot be interpreted as meaning that tree voles had limited populations or were historically absent from an area, especially if that area formerly provided suitable forest habitat for tree voles and was contiguous with known occupied areas. Surveys by naturalists in the late 1800s and early 1900s were more of an inventory to find new species and to determine species presence as opposed to determining abundance of a particular species (Jobanek 1988, p. 370). Only portions of Oregon were surveyed, and coverage was cursory and localized. Given the arboreal existence of the red tree vole and difficulty of finding and observing them, few specimens were collected or observed until more was understood about their life history (Bailey 1936, p. 195; Jobanek 1988, pp. 380-381). Many nests were simply inaccessible to early naturalists. Nests were often high up in big trees, many of which were too large to climb without the benefit of climbing equipment, or the trees lacked enough branches on the lower bole to readily free-climb (e.g., Jobanek 1988, p. 391). Howell (1921, p. 99) noted that there was little hope for finding tree voles in virgin timber because large trees and the abundant moss often conceal hidden nests. Vernon Bailey, Chief Naturalist of the U.S. Bureau of Biological Survey, considered the red tree vole to be abundant in the wild yet rare in museum collections because of the difficulty in collecting them (Jobanek 1988, p. 382). Murray Johnson, the most prolific early collector of tree voles, spent most of his time searching in young forests because he could not climb big trees (Forsman 2010, pers. comm.).

Descriptions of historical search efforts for red and Sonoma tree voles indicate that once the species behavior and life history were understood, searchers were more successful in finding tree voles, often with little difficulty. Observers typically noted the patchy distribution of voles, and once they found voles, they tended to readily find multiple nests and voles in the same area (Taylor 1915, pp. 140-141; Howell 1926, pp. 42-43; Clifton 1960, pp. 24-30; Maser 1966, pp. 170, 216-217; Maser 2009, pers. comm.; Forsman and Swingle 2010, p. 104). For example, Clifton (1960, pp. 24-30) averaged one day searching for every red tree vole colony found near Newberg, Oregon, and Howell described more than 50 Sonoma tree voles being collected over two days near Carlotta, California in 1913 (Howell 1926, p. 43).

In contrast, between 2002 and 2006, Forsman and Swingle (2006, unpublished data) spent 1,143 person-hours searching potential vole habitat in or near areas where voles historically occurred or immediately adjacent to the DPS and captured or observed only 27 voles, equating to 42 hours of search effort per vole found. Similarly, on the Clatsop and Tillamook State Forests, Price et al. (2015, p. 43) spent 50 person-hours per nest found. Although a rigorous quantitative comparison cannot be made between recent and historical observation data, the above anecdotal information indicates that tree vole numbers are greatly reduced in the DPS and red tree voles are now scarce in the same areas where they were once found with relative ease. Similarly, decreases in Sonoma tree vole numbers have been observed, although not quantified, over the past decade (Diller 2010, pers. comm.). The weight of evidence suggesting that tree voles are less abundant now increases upon considering that most historical observations were by naturalists who primarily collected voles from younger forests where nests were more easily observable and accessible by free-climbing (e.g., Howell 1926, p. 42; Clifton 1960, p. 34; Maser 2009, pers. comm.; Forsman 2010, pers. comm.). These early naturalists were limited in their sampling by the size and form (e.g., presence or absence of low-lying limbs that allowed for free-climbing) of trees they could climb, unlike current researchers, yet found many voles with relatively little effort. In contrast, researchers in recent years searching these same areas have captured comparatively few voles per unit effort, using state-of-the-art climbing gear to access every potential nest observed, regardless of tree form or size (Forsman 2009, pers. comm.; Forsman and Swingle 2006, unpublished data; 2009, pers. comm.). Although rigorous population estimates cannot be determined from these data, the evidence suggests that red tree voles are now much less abundant within the DPS than they were historically.

Distinct Population Segment(DPS):

The U.S. Fish and Wildlife Service (Service) and the National Marine Fisheries Service published the Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (DPS Policy) in the Federal Register on February 7, 1996 (61 FR 4722), to guide the implementation of the DPS provisions of the Act. Under the DPS Policy, three elements are considered in the decision regarding the establishment and classification of a population of a vertebrate species as a possible DPS. These are applied similarly for additions to and removals from the Lists of Endangered and Threatened Wildlife and Plants. These elements are:

1. The discreteness of a population in relation to the remainder of the species to which it belongs;
2. The significance of the population segment to the species to which it belongs; and
3. The population segments conservation status in relation to the Acts standards for listing, delisting, or reclassification (i.e., is the population segment endangered or threatened?).

Discreteness is evaluated based on specific criteria provided in the DPS Policy. If a population segment is considered discrete under the DPS Policy we must then consider whether the discrete segment is significant to the taxon to which it belongs. If we determine that a population segment is discrete and significant, we then evaluate it for endangered or threatened status based on the Acts standards. The DPS evaluation in this finding concerns the North Oregon Coast Range portion of the red tree vole. Specific to red tree vole genetics, in this section we have reviewed the research on red tree vole genetics and evaluated whether or not the genetics evidence supports identifying a population segment that meets the discreteness and significance standards described above. Although genetic research indicates that the putative dusky tree vole may not be a valid subspecies (e.g., Bellinger et al. 2005, entire; Miller et al. 2010, entire), whether or not a population segment is discrete and significant is a different question and these works do not exclude the possibility that there is a discrete and significant population segment for the red tree vole.

Discreteness

The DPS Policy’s standard for discreteness requires an entity to be adequately defined and described in some way that distinguishes it from other representatives of its species. A population segment of a vertebrate species may be considered discrete if it satisfies either of the following two conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or
2. It is delimited by international governmental boundaries within which significant differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist.

The North Oregon Coast portion of the red tree vole range is markedly separated from the rest of the species range based on the genetic discontinuities described by Miller et al. (2006a, pp. 150-151). Miller et al. (2006a, entire) examined phylogeographical patterns by analyzing mitochondrial control region sequences of 169 red tree voles sampled from 18 areas across the range of the species in Oregon. In addition, they analyzed Cytochrome-b sequences from a subset of these samples. Through phylogenetic network and spatial genetic analyses, the researchers found a primary genetic discontinuity dividing red tree voles into northern (areas A through F in

Miller et al. 2006a, Figure 1, pp. 146, 151-152) and southern (areas G through R in Miller et al. 2006a, Figure 1, pp. 146, 151-152) sampling areas; a secondary discontinuity separated voles in the northern sampling area into eastern (areas B, E, and G in Miller et al. 2006a, Figure 1, pp. 146, 151-152) and western (areas A, C, D, and F in Miller et al. 2006a, Figure 1, pp. 146, 151-152) subdivisions separated by the Willamette Valley (Miller et al. 2006a, pp. 150-153). Miller et al. (2006a, p. 151) labeled the eastern subdivision as the Northern Cascade range sequence, and the western subdivision the Northern Coast range sequence, reflecting the associated mountain ranges. As described in the Taxonomy and Description section, above, researchers considered the degree of genetic difference between the 3 groupings of red tree voles to be highly significant (Miller and Haig 2009, pers. comm.). We thus consider the population of red tree voles represented by the Northern Coast range haplotypes to be markedly separated from other populations of the taxon as evidenced by quantitative measures of genetic discontinuity.

Red tree voles within the Northern Coast range haplotype (genetic) group identified by Miller et al. (2006a, pp. 150-151) came from several specific sampling locations, but the researchers did not attempt to delineate precise boundaries between the three genetic groupings of red tree voles in Oregon. We have therefore defined the boundary of the northern Coast Range population of red tree voles based on a combination of convergent genetic, physical, and ecological characteristics. To assist in this delineation, we relied in part on the physiographic provinces used in the NWFP because they incorporate physical, biological, and environmental factors that shape large landscapes (FEMAT 1993, p. IV-5). In addition, much of the forest-related research relevant to our analysis has been based on these province delineations. We interpret the area occupied by the Northern Coast range genetic group of red tree voles to include that portion of the Oregon Coast Range Physiographic Province (FEMAT 1993, pp. II-27, IV-7) from the Columbia River south to the Siuslaw River. In addition, the Willamette Valley to the east of the northern Oregon Coast Range provides a geographic barrier for genetic exchange between red tree voles found in the northern Oregon Coast Range and those found in the northern Cascade Range; the western edge of the Willamette Valley thus forms a natural eastern boundary for the red tree vole population in the northern Oregon Coast Range.

As for the southern limit of the Northern Coast range haplotypes, there is no identifiable geographic boundary that may act as a genetic barrier. We chose the Siuslaw River as an identifiable feature that approximates a divide between southern and northern haplotypes in the Oregon Coast Range as described in Miller et al. (2006a, pp. 150-151). This is an area where vegetation transitions from more mesic vegetation species in the north to drier vegetation in the south (Franklin and Dyrness 1973, p. 72; McCain 2009, pers. comm.). In addition, the Siuslaw River creates an approximate break between ecosystems that experience longer fire return intervals to the north and shorter return intervals to the south (Hardt 2009, pers. comm.). This area transitions into the southern end of the western hemlock vegetation zone, which has a patchier fire severity distribution as compared to the northern Oregon Coast Range, which is characterized by high fire severities (Agee 1993, pp. 211-213). This delineation of the boundary of the northern Oregon Coast Range population of the red tree vole, described above, is shown in Figure 2.

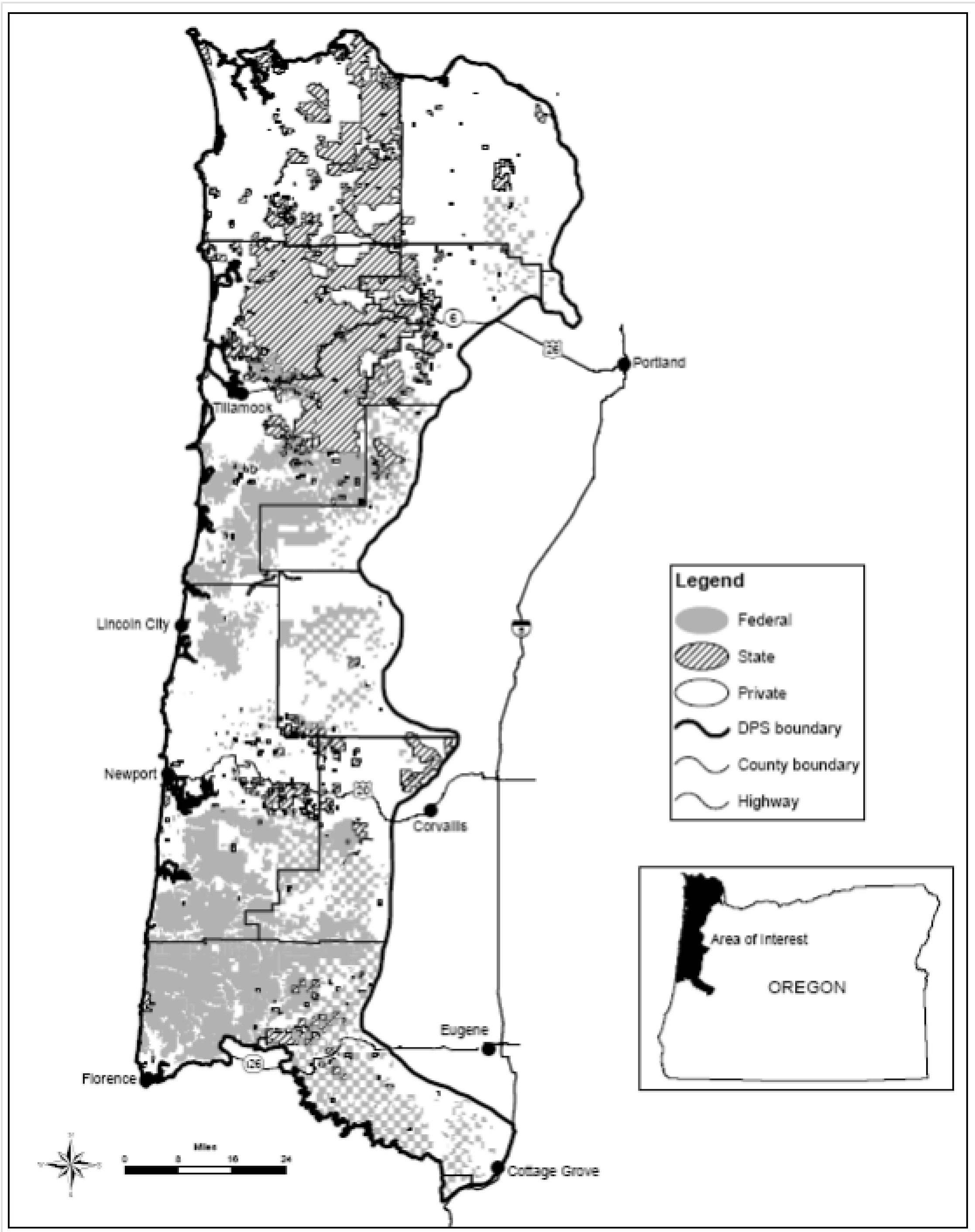

Figure 2. North Oregon Coast distinct population segment (DPS) of the red tree vole.

There is some overlap of haplotypes in the lineage of sequences unique to the northern Oregon Coast Range and the southern portion of the tree vole range (Miller et al. 2006a, pp. 153-154). This overlap, combined with the absence of an obvious geographical barrier to genetic interchange, leads to a hypothesis that the observed genetic discontinuity in this area represents a zone of secondary contact between lineages that were divided during the most recent glaciation approximately 12,000 years ago (Miller et al. 2006a, p. 154). Although the Cordilleran ice sheet of

the Wisconsin glaciation did not overlay present-day Oregon, associated climate change during the glaciation fragmented the forest landscape (Bonnicksen 2000, pp. 8-10, 15-16, 24-25). Subalpine forests occupied much of northwestern Oregon, with western hemlock and Sitka spruce remaining only in isolated, protected areas (Bonnicksen 2000, p. 25). These potential bottlenecks in northern populations may have divided red tree voles into separate lineages that continue to exist today (Miller et al. 2006a, p. 154). A similar genetic discontinuity is found in the southern torrent salamander (Rhyacotriton variegatus) in this vicinity (Miller et al. 2006b, p. 565). In addition, other plant and mammal species exhibit north-south genetic discontinuities in this area of western Oregon (Soltis et al. 1997, pp.
353-359; Himes 2008, pp. 63-65).

We conclude that the North Oregon Coast population of the red tree vole is markedly separated from the remainder of the red tree vole population and meets the discreteness criterion for the DPS Policy based on quantitative measures of genetic discontinuity. Genetic distribution in the red tree vole is not random, with a markedly distinct group of haplotypes located in the northern Oregon coast. The Willamette Valley likely serves as a genetic barrier between the North Oregon Coast tree vole population and tree voles in the northern Cascades. While there is no currently identifiable geographic barrier to the south, glacial activity at the end of the Pleistocene Epoch may have been responsible for creating multiple lineages of red tree voles, as well as other species, that are still identifiable today. The Siuslaw River is an identifiable feature that appears to approximately coincide with the southernmost boundary of the Northern Coast range genetic group of the red tree vole, as identified in Miller et al. (2006a, p. 151).

Significance

If we have determined that a vertebrate population segment is discrete under our DPS Policy, we then consider its biological and ecological significance to the taxon to which it belongs in light of Congressional guidance (see Senate Report 151, 96th Congress, 1st Session) that the authority to list a DPS be used sparingly while encouraging the conservation of genetic diversity. To evaluate whether a discrete vertebrate population may be significant to the taxon to which it belongs, we consider the best available scientific evidence. As precise circumstances are likely to vary considerably from case to case, the DPS Policy does not describe all the classes of information that might be used in determining the biological and ecological significance of a discrete population. However, the DPS Policy describes four possible classes of information that provide evidence of a population segments biological and ecological significance to the taxon to which it belongs. This evaluation may include, but is not limited to:

1. Persistence of the discrete population segment in an ecological setting that is unusual or unique for the taxon;
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon;
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; or

4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Persistence of the DPS in an ecological setting that is unique or unusual for the taxon.

The Sitka spruce plant series in the northern Oregon coast appears to be a unique ecological setting for a portion of the population of the red tree vole that was determined to be discrete. The Sitka spruce series occurs in the strongly maritime climate near the ocean, following the coastal fog up river valleys. Sitka spruce occurs from south-central Alaska to northern California, with the most extensive portion of its range occurring in southeastern Alaska and northern British Columbia, Canada (Burns and Honkala 1990, Sitka spruce chapter). Although present at some level along most of the Oregon coastline, its distribution is more restricted in this southern portion of its range, although it extends much farther inland at the northern part of the Oregon Coast Range than in the southern portion, where ridge systems along the coastline intercept the fog layer (Franklin and Dyrness 1973, pp. 58-70; McCain and Diaz 2002, p. 59). With the exception of scattered small patches on the southern and central Oregon coast, the majority of the Sitka spruce plant series in Oregon lies in the area encompassed by the North Oregon Coast population of red tree voles (McCain and Diaz 2002, p. 61). It is in the Sitka spruce plant series that the alternative tree vole diet of western hemlock and Sitka spruce needles predominates (see Diet section). Douglas-fir appears to have been historically uncommon in the Sitka spruce series (Agee 1993, p. 194). Little variation in annual temperature, minor summer plant moisture stress, and very high precipitation make the Sitka spruce series extremely productive, producing large trees relatively quickly, and containing plant associations that tend to develop and maintain older forest characteristics important to a variety of wildlife species.

The Sitka spruce plant series is the only known portion of the red tree vole range where the consumption of western hemlock and Sitka spruce is the dominant foraging behavior. Within the extent of the Northern Coast range genetic grouping identified by Miller et al. (2006a, p. 151), this behavior is exhibited by tree voles in the western portions of Lincoln, Tillamook, and Clatsop counties. There have been only infrequent occurrences of individual red tree voles foraging on species other than Douglas-fir; and red tree voles are not known to subsist primarily on a species other than Douglas-fir anywhere else in the range. . This alternative diet appears well ingrained, as evidenced by wild voles adapted to a diet of western hemlock refusing to eat Douglas-fir in captivity and ultimately starving to death (Maser 2009, pers. comm.). This ecological setting has resulted in a foraging behavior that appears relatively inflexible and unique to the red tree voles in this area, as red tree voles in forests dominated by Douglas-fir apparently exhibit greater behavioral plasticity and have been observed to eat western hemlock and Sitka spruce in captivity (Clifton 1960, p. 44; Maser 2009, pers. comm.).

The different foraging behaviors exhibited by red tree voles are likely a consequence of adaptation to different selective pressures caused by the different plant series that occur in the northern Oregon Coast Range. Such selective pressures are the foundation of speciation, and such distinct traits may be crucial to species adaptation in the face of changing environments (Lesica and Allendorf 1995, p. 756). We find the discrete population of tree voles in the northern Oregon Coast

Range contains a unique ecological setting in the form of the Sitka spruce plant series because the plant series is extremely limited within the red tree vole range, and because the relatively unique and inflexible foraging behavior tied to this plant series may be indicative of ongoing speciation. However, the geographic range in which this ecological setting and associated unusual foraging behavior is expressed does not correspond to the range of the tree voles identified under the discreteness criterion, above, as it occurs in only a subset of the range of tree voles with the Northern Coast range genetic grouping identified in Miller et al. (2006a, p. 151). Therefore, although we recognize this ecological setting and the associated unique foraging behavior of tree voles to be potentially important from an evolutionary perspective, we find that the discrete population of tree voles in the northern Coast Range as a whole does not meet this significance criterion under the DPS policy.

Evidence that loss of the DPS would result in a significant gap in the range of the taxon.

The loss of the North Oregon Coast portion of the red tree vole range would result in a roughly 24 percent reduction in the range of the red tree vole. This loss is significant for multiple reasons, in addition to the fact that it represents nearly one-quarter of the total range of the species. For one, it would occur in the only part of the range where the alternative foraging behavior of feeding on spruce and hemlock is observed. Although this behavior is expressed in only a subset of this portion of the range, it is of potential evolutionary significance; therefore, its loss would be significant to the taxon as a whole. Secondly, while loss of the North Oregon Coast population would not create discontinuity in the remaining range, species at the edge of their range may be important in maintaining opportunities for speciation and future biodiversity (Fraser 1999, p. 50), allowing adaptation to future environmental changes (Lesica and Allendorf 1995, p. 756). Furthermore, peripheral populations may represent refugia for species as their range is reduced, as described by Lomolino and Channell (1995, p. 339), who found range collapses in mammal species to be directed towards the periphery. Genetically divergent peripheral populations, such as the North Oregon Coast population of the red tree vole, are often of disproportionate importance to the species in terms of maintaining genetic diversity and the capacity for evolutionary adaptation (Lesica and Allendorf 1995, p. 756). Finally, in the face of predictions that climate change will result in species ranges shifting northward and to higher elevations (Parmesan 2006, pp. 648-649; IPCC 2014, p. 51; Marris 2007, entire; Romero-Lankao et al. 2014, p. 1458) (see Factor E. Other Natural or Manmade Factors Affecting the Species Continued Existence), the northern Oregon Coast Range may become a valuable refugium from climate change effects for the species because it includes the northernmost portion of the red tree vole range as well as higher elevations near the Oregon Coast Range summit. Based on the above considerations, we therefore conclude that loss of the North Oregon Coast population of the red tree vole would result in a significant gap in the range of the taxon.

Evidence that the DPS represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range.

As part of a determination of significance, our DPS Policy suggests that we consider whether there is evidence that the population represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range. The North Oregon Coast population of the red tree vole is not the only surviving natural occurrence of the species and has not been introduced outside of its historical range. Consequently, this factor is not relevant to our determination regarding significance.

Evidence that the DPS differs markedly from other populations of the species in its genetic characteristics.

Red tree voles exhibit marked genetic structure. As described under Discreteness, above, Miller et al. (2006a, entire) characterized patterns of genetic divergence across the range of the red tree vole in western Oregon based on analyses of mitochondrial DNA from 18 sampling areas. The results of their spatial analysis of molecular variance revealed three distinct genetic groupings of red tree voles in Oregon: a southern haplotype group, and a northern haplotype group that was further subdivided into two groups, the Northern Cascade range and Northern Coast range groups (Miller et al. 2006a, pp. 150-151). The sampling areas that correspond to the Northern Coast range subdivision of the northern group (Areas A, C, D, and F) correspond to the entity we have described here as the North Oregon Coast population of the red tree vole. In the 4 sampling areas for the Northern Coast range genetic sequence (Miller et al. 2006a, p. 151), 20 out of the 21 D-loop haplotypes identified were unique to those locations, and in 3 of 4 sampling areas, 100 percent of the individuals sampled had a location-specific haplotype (60 percent of the individuals had a location-specific haplotype in the fourth sampling area; a single haplotype from Area C was also detected in Area N (the southern haplotype group) (Miller et al. 2006a, Table 1, p. 148; Appendix, pp. 158-159). The researchers could not identify a strict discontinuity or barrier between the northern and southern groupings where the greatest genetic distances were observed; they did suggest, however, that the Willamette Valley serves as an important phylogeographical barrier that is likely responsible for the secondary genetic discontinuity identified between red tree voles in the western (Northern Coast range sequence) and eastern (Northern Cascade range sequence) portions of the northern haplotypes group (Miller et al. 2006a, pp. 151, 155).

Loss of the North Oregon Coast population of the red tree vole would eliminate a unique set of genetic haplotypes from the red tree vole population. Retaining genetic variation provides a wider capability for species to adapt to changing environmental conditions (Frankham et al. 2002, p. 46). Peripheral populations that are known to be genetically divergent from other conspecific populations, such as the North Oregon Coast population of the red tree vole, may have great conservation value in providing a species with the capacity to adapt and evolve in response to accelerated environmental changes (Lesica and Allendorf 1995, p. 757). Changing environmental conditions are almost a certainty for the red tree vole, given the prevailing recognition that warming of the climate system is unequivocal (IPCC 2014, p. 2). The importance of maximizing the genetic capacity to adapt and respond to the environmental changes anticipated is therefore magnified. Furthermore, preservation of red tree voles and their unique genetic composition at the northern extent of their range may be particularly important in the face of climate change, as species are shifting their ranges northward in response to that phenomenon, and species that cannot shift northward have suffered range contractions from loss of the southernmost populations, or localized extinctions (Parmesan 2006, pp. 647-648, 753; Groffman et al. 2014, p. 200; IPCC 2014, p. 51;

Romero-Lankao et al. 2014, p. 1458). Given that the Columbia River presents an apparent absolute barrier to northward expansion of the species, the northern Coast Range population of the red tree vole may provide an important refugium for the persistence of the species if more southerly populations are extirpated in the face of climate change. Losing an entire unique genetic component of the red tree vole, with its inherent adaptive capabilities, is significant and could compromise the long-term viability of the species as a whole. We therefore conclude the marked difference in genetic characteristics of the North Oregon Coast population relative to other populations of the red tree vole meets the significance criterion of the DPS Policy.

DPS Conclusion

We have evaluated the North Oregon Coast population of the red tree vole to determine whether it meets the definition of a DPS, addressing discreteness and significance as required by our policy. We have considered the genetic differences of the North Oregon Coast population relative to the remainder of the taxon, the ecological setting of the northern Oregon Coast Range, and the proportion of the range of the red tree vole that the North Oregon Coast population comprises. We conclude that the North Oregon Coast population of the red tree vole is a valid distinct population segment under the 1996 DPS Policy (Figure 2). The North Oregon Coast population meets the discreteness criterion of the DPS Policy because it is markedly separated from the remainder of the taxon based on genetic differences. Genetic distribution in the red tree vole is not random, but exhibits a markedly distinct group of haplotypes located in the northern Oregon Coast Range (Miller et al. 2006a, entire). We also conclude that the North Oregon Coast population of red tree voles is significant on multiple accounts. The loss of this population would virtually eliminate a unique genetic component of the red tree vole, substantially reducing genetic diversity and consequently limiting the species ability to evolve and adapt to changing environments. Loss of this population, which comprises 24 percent of the range of the red tree vole, would result in a significant gap in the range, primarily because of the value of peripheral populations in maintaining diversity and evolutionary adaptation, and because this area may provide a valuable refugium in the event of predicted climate change. The loss of red tree voles in the northern Oregon Coast Range would also result in the loss of a unique alternative foraging behavior exhibited by tree voles in the Sitka spruce plant series. Although this behavior occurs in a subset of the area encompassed by the North Oregon Coast population (Forsman and Swingle 2009, unpublished data), it is of potential evolutionary significance to the species; therefore the loss of that portion of the species range that includes this subpopulation would be of significance to the taxon as a whole.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Past and Current Range and Abundance

Tree voles seem to be widely distributed throughout much of their range in Oregon with the exception of the northern Oregon Coast Range (USDA and USDI 2000a, p. 376; USDA and USDI

2007, pp. 289-290). This is especially true in the area within the DPS north of U.S. Highway 20, where tree voles are now considered uncommon and sparsely distributed compared to the rest of the range, based on observations of vole nests classified as recently occupied (USDA and USDI 2007, pp. 289, 294). Furthermore, the few nests that were recorded in this portion of the DPS likely result in overestimation of tree vole occupancy given errors in nest activity classification (USDA and USDI 2007, p. 290) and the difficulty in translating nest counts to vole numbers discussed earlier in this section. Tree voles in this portion of the DPS appear to be limited to scattered locations along the coast up to about 15 km (9 mi) inland, seemingly eliminated from much of the area by fire, logging, and landscape conversion to industrial forests (Price et al. 2015, p. 45).

Although a rigorous quantitative comparison cannot be made between recent and historical observation data, anecdotal information indicates that tree vole numbers are greatly reduced in the DPS, being scarce in the same areas where they were once found with relative ease. The weight of evidence suggesting that tree voles are less abundant now increases upon considering that most historical observations were by naturalists who primarily collected voles from younger forests where nests were more easily observable and accessible by free-climbing (e.g., Howell 1926, p. 42; Clifton 1960, p. 34; Maser 2009, pers. comm.; Forsman 2010, pers. comm.) (See Population Estimates/Status). Although rigorous population estimates cannot be determined from these data, the evidence suggests that red tree voles are now much less abundant within the DPS than they were historically.

Habitat loss appears to at least partly explain the apparent reduction in tree vole numbers, both rangewide and within the DPS. Habitat loss and degradation has been observed in areas of the North Oregon Coast DPS where tree voles historically occurred and is especially prominent in coastal areas and along the Willamette Valley margin where some of the historical collecting sites have been logged and fewer voles are now present (Forsman and Swingle 2009, unpublished data; Forsman 2009, pers. comm.). The apparently significant decline in tree vole abundance within the North Oregon Coast DPS of the red tree vole appears to correspond with the extensive historical loss of the older forest type that provides the highest quality habitat for the red tree vole, as well as the ongoing harvest of timber on short rotation schedules that maintains the remaining forest in lower quality early seral conditions in perpetuity. In addition, continuing timber harvest in younger forest areas adjacent to remaining patches of older forest diminishes the habitat quality of these stands by maintaining them in an isolated and fragmented condition that may not allow for persistent populations of red tree voles.

Landscapes in the Oregon Coast Range have become increasingly fragmented and dominated by younger patches of forest, as old and mature forests have been converted to younger stands through anthropogenic alteration (Wimberly et al. 2000, p. 175; Martin and McComb 2002, p. 255; Wimberly 2002, p. 1322; Wimberly et al. 2004, p. 152; Wimberly and Ohmann 2004, pp. 631, 635, 642). The historical loss of large contiguous stands of older forest has manifested in the current primary threats to the North Oregon Coast DPS of the red tree vole of insufficient habitat, habitat fragmentation, and isolation of small populations; these threats are addressed under Factor E, below. Here we address the effects of varying levels of ongoing habitat loss and modification in the North Oregon Coast DPS of the red tree vole. We first provide some background on the historical environmental conditions in the DPS, as this provides important context for understanding the effects of ongoing timber harvest on the habitat of the red tree vole.

Modification of Oregon Coast Range Vegetation

Within the Oregon Coast Range Province, the type of forest habitat favored by red tree voles has experienced significant loss over the past century, primarily due to timber harvest. While the total area of closed canopy forest remained fairly stable from 1936 to 1996, major shifts have occurred in the distribution, age, and structure of these forested cover classes. There has been a change from a landscape dominated by large conifers with quadratic mean tree diameters greater than or equal to 51 cm (20 in) to a landscape dominated by smaller conifers which provide habitat that may be less suitable for tree voles. Specifically, the percent cover of large conifers in the Coast Range Province declined from 42 percent in 1936 to 17 percent in 1996 (Wimberly and Ohmann 2004, p. 631). On Federal lands, timber harvest has declined substantially since the inception of the NWFP in 1994 (Spies et al. 2007a, p. 7). Though not statistically significant, Moeur et al. (2011, pp. 15-17, Table 6) found a slight reduction in older forest habitat (minimum quadratic mean diameter 20 in (51 cm) and canopy cover greater than 10 percent) on Federal lands in the Oregon Coast Range since the inception of the NWFP. By comparison, older forest habitat on non-Federal lands decreased by 17 percent (Moeur et al. 2011, p. 18, Table 7).

There is some indication that managed second-growth forests are not developing characteristics identical to natural late-successional forests, and that second-growth forests and clearcuts exhibit reduced diversity of native mammals typically associated with old-growth forest conditions (Lomolino and Perault 2000, pp. 1526, 1529). The historical losses of late-successional forest and ongoing management of most forests on State, County, and private lands for harvest on a short-rotation schedule have resulted in the destruction of the older forest habitats favored by red tree voles; these older forest habitats now persist largely in small, isolated fragments across the DPS. Because of the historical loss of older forest stands, the remaining habitat now contains forests in earlier seral stages, which provide lower-quality habitat for red tree voles. The ongoing management of much of the forest within the DPS for timber harvest on relatively short rotation schedules, particularly on State, County, and private lands, contributes to the ongoing modification of tree vole habitat by maintaining forests in low quality condition; most of the younger forest types within the DPS are avoided by tree voles for nesting. Although younger forests may provide important interim or dispersal habitats for red tree voles, it is unlikely that forests lacking the complexity and structural characteristics typical of older forests can support viable populations of red tree voles over the long term. These concepts are explored further in the section, Continuing Modification and Current Condition of Red Tree Vole Habitat, below.

Habitat Loss from Timber Harvest

In their analysis of forest trends in the Oregon Coast Range, Wimberly and Ohmann (2004, p. 643) found that land ownership had the greatest influence on changes in forest structure between 1936 and 1996, with State and Federal ownership retaining more large-conifer structure than private lands. Loss of large-conifer stands to development was not considered a primary cause of forest type change. Instead, loss to disturbance, primarily timber harvest, was the biggest cause, with fires accounting for a small portion of the loss (Wimberly and Ohmann 2004, pp. 643-644). Between 1972 and 1995, timber clearcut harvest rates in all stand types were nearly three times higher on private land (1.7 percent of private land per year) than public land (0.6 percent of public land per year), with the Coast Range dominated by private industrial ownership and having the greatest amount of timber harvest as compared to the adjacent Klamath Mountain and Western Cascades Provinces (Cohen et al. 2002, pp. 122, 124, 128). Within the Coast Range, there has been a substantial shift in timber harvest from Federal to State and private lands since the 1980s, with an 80 to 90 percent reduction in timber harvest rates on Federal lands (Azuma et al. 2004, p. 1; Spies et al. 2007b, p. 50).

More than 75 percent of the future tree harvest is expected to come from private timberlands (Johnson et al. 2007, entire; Spies et al. 2007b, p. 50) and modeling of future timber harvests over the next 50 years indicates that current harvest levels on private lands in western Oregon can be maintained at that rate (Adams and Latta 2007, p. 13). Loss and modification of tree vole habitat within the northern Oregon Coast Range, as well as timber management that limits habitat development, is thus expected to continue, albeit at a lower rate on State and Federal lands compared to private lands (see discussion under Factor D, below). However, even on Federal lands, which provide the majority of remaining suitable habitat for red tree voles within the DPS, some timber harvest is expected to continue in those land allocations where allowed under their management plans. Although some forms of harvest may not exert a significant negative impact on red tree voles if managed appropriately (for example, thinning in Late-Successional Reserves (LSRs) with the goal of enhancing late-successional characteristics over the long term), lands in the Matrix allocation are intended for multiple uses, including timber harvest. As an example, since the inception of the NWFP, 55 percent of the timber harvest on BLM lands within the DPS came from the Matrix allocation, 20 percent from Adaptive Management Areas (AMAs), and 25 percent came from LSRs both within and outside the AMA (BLM 2010, unpublished data). These numbers do not include harvest within Riparian Reserves, which overlay all land allocations. Within the DPS, approximately 156,844 ac (63,475 ha) are in the Matrix allocation.

Continuing Modification and Current Condition of Red Tree Vole Habitat

The loss of much of the older forest within the DPS has reduced high-quality habitat for tree voles to relatively small, isolated patches; these conditions pose a significant threat to red tree voles, which are especially vulnerable to the effects of isolation and fragmentation due to their life-history characteristics (see Factor E, below). Tree voles are naturally associated with unfragmented landscapes, and are considered habitat specialists that select areas of contiguous mature forest; they are not adapted to fragmented landscapes and early seral habitat patches (Martin and McComb 2002, p. 262). At present and for the foreseeable future, however, much of the remaining forest on State and private lands in the North Coast Range DPS is managed for timber production, as are lands within the Matrix allocation of the Federal lands (see Factor D below).

Managing for timber production either removes existing habitat or prevents younger stands from developing into suitable habitat due to short harvest rotations. Remaining older forest habitat tends to be in small, isolated patches (see Factor E below); we consider such forest conditions to provide poor habitat for the red tree vole and unlikely to sustain the species over the long term. Although some State land and much of the Federal ownership is managed for development or maintenance of late-successional habitat or old-forest structure conditions, active management such as thinning activities are allowed and encouraged to develop the desired stand conditions. However, thinning stands occupied by tree voles can reduce vole numbers or eliminate them (see below).

The most comprehensive analysis of current red tree vole habitat conditions specific to the North Coast Range DPS is a report by Dunk (2009, entire). Dunk (2009, p. 1) applied a red tree vole habitat suitability model (Dunk and Hawley 2009, entire) to 388 Forest Inventory Analysis (FIA) plots systematically distributed on all ownerships throughout the DPS (the FIA is a program administered by the USDA Forest Service, and is a national scientific inventory system based on permanent plots designed to monitor the status, conditions, and trends of U.S. forests). FIA plots are resampled every 10 years to monitor changes in forest vegetation. The red tree vole habitat suitability model estimates the probability of red tree vole nest presence (Po) from 0 to 1; the larger values of Po (e.g., 0.9 or 0.8) represent a greater probability of nest presence and correlate to presumed higher quality habitat. Based on their model results, Dunk and Hawley (2009, p. 630) considered a Po of greater than or equal to 0.25 as likely having presence of a tree vole nest in an FIA plot; a Po of less than 0.25 was considered as not likely to have a tree vole nest. The Po cutoff point of 0.25 represents the value that achieved the highest correct classification of occupied and non-occupied sites while attempting to reduce the error of misclassifying plots that actually had nests as plots without nests; plots with Po greater than 0.25 are assumed to represent suitable tree vole habitat. Based on this assumption that a Po value of 0.25 represents suitable tree vole habitat, Dunk (2009, pp. 4, 7) found that 30 percent of the plots on Federal lands within the DPS had suitable habitat, but only 4 and 5 percent of the plots on private and State lands within the DPS, respectively, had suitable habitat. Across all landownerships in the DPS collectively, 11 percent of the plots had potentially suitable habitat for red tree voles. Thus within the DPS, there is relatively little suitable habitat remaining for the red tree vole, and this suitable habitat is largely restricted to Federal lands. State and private lands, which comprise the majority of the DPS (78 percent of the land area), provide little suitable habitat for tree voles.

Dunk and Hawley (2009, p. 631) also compared red tree vole usage of forest types with their proportional availability on the landscape; this is an important measure of habitat selection by the species. If red tree voles do not select for any particular forest type condition, we would expect different forest types to be used by tree voles in proportion to their availability. If a forest type is used less than expected based on its availability, that is assumed to represent selection against that forest type; in other words, the species avoids using that forest type, even though it is available. If a forest type is used more than expected based on availability, that is assumed to represent selection for that forest type; the species is seeking out that forest type, despite the fact that the forest type is less readily available. The forest type that tree voles select is assumed to be suitable habitat.

Combining the strength of selection analysis by Dunk and Hawley (2009, p. 631) with the current habitat condition in the DPS based on FIA data, almost 90 percent of the DPS is in a forest type condition that red tree voles tend to avoid, while only 0.3 percent of the DPS is in a forest type that red tree voles tend to strongly select for (Figure 3). This is based on evaluation of the FIA plots, comparing those with the lowest probability of selection by tree voles for nesting (lowest 20 percent of probability classes; nearly 87.3 percent of FIA plots across all landownerships within the DPS were in this condition) with those with the greatest strength of selection (highest 20 percent of probability classes; 0.3 percent of FIA plots across all landownerships were in this condition). Assuming that tree voles exhibit the strongest selection for the highest quality habitats, this translates into roughly 11,605 ac (4,700 ha) of high-quality habitat remaining for red tree voles distributed across a DPS roughly 3.8 million ac (1.6 million ha) in size. Furthermore, although some nests may have been missed during tree vole surveys, the nest estimates used by Dunk and Hawley (2009, entire), and subsequently applied by Dunk (2009, entire), likely overestimate probable tree vole occupancy for two reasons. First, occupied sites were based on locations of tree vole nests, and as explained earlier, the presence of nests, even those classified as active, do not necessarily equate to tree vole occupancy.

Second, the analyses were based on plot-level data at the scale of less than 1 ha (2.5 ac). The distribution of tree vole habitat and effects of habitat fragmentation, connectivity, and possible metapopulation dynamics may also influence the presence of tree voles on a site such that a 1 ha (2.5 ac) plot of highly suitable habitat isolated from other suitable habitat is less likely to contain or sustain tree voles than connected stands (Dunk 2009, p. 9). Thus, its actual likelihood of occupancy may be lower than predicted by the model due to its landscape context. The sample patch size used by Dunk (2009, entire) is less than the 2 to 4 ha (5 to 10 ac) in which Hopkins (2010, pers. comm.) found nests and substantially less than the minimum forest stand size of 30 ha (75 ac) in which individuals have been found (Huff et al. 1992, p. 7). Whether either of these minimum patch sizes can sustain a population of red tree voles over the long term is unknown and is influenced by such factors as habitat quality within and surrounding the stand, position of the stand within the landscape, and the ability of individuals to move among stands (Huff et al. 1992, p. 7; Martin and McComb 2003, pp. 571-579). Given the conservative assumptions of the model, the amount of remaining likely suitable habitat within the DPS reported by Dunk (2009, entire) may represent a best-case scenario, and the amount of remaining habitat suitable for red tree voles is likely less than estimated here.

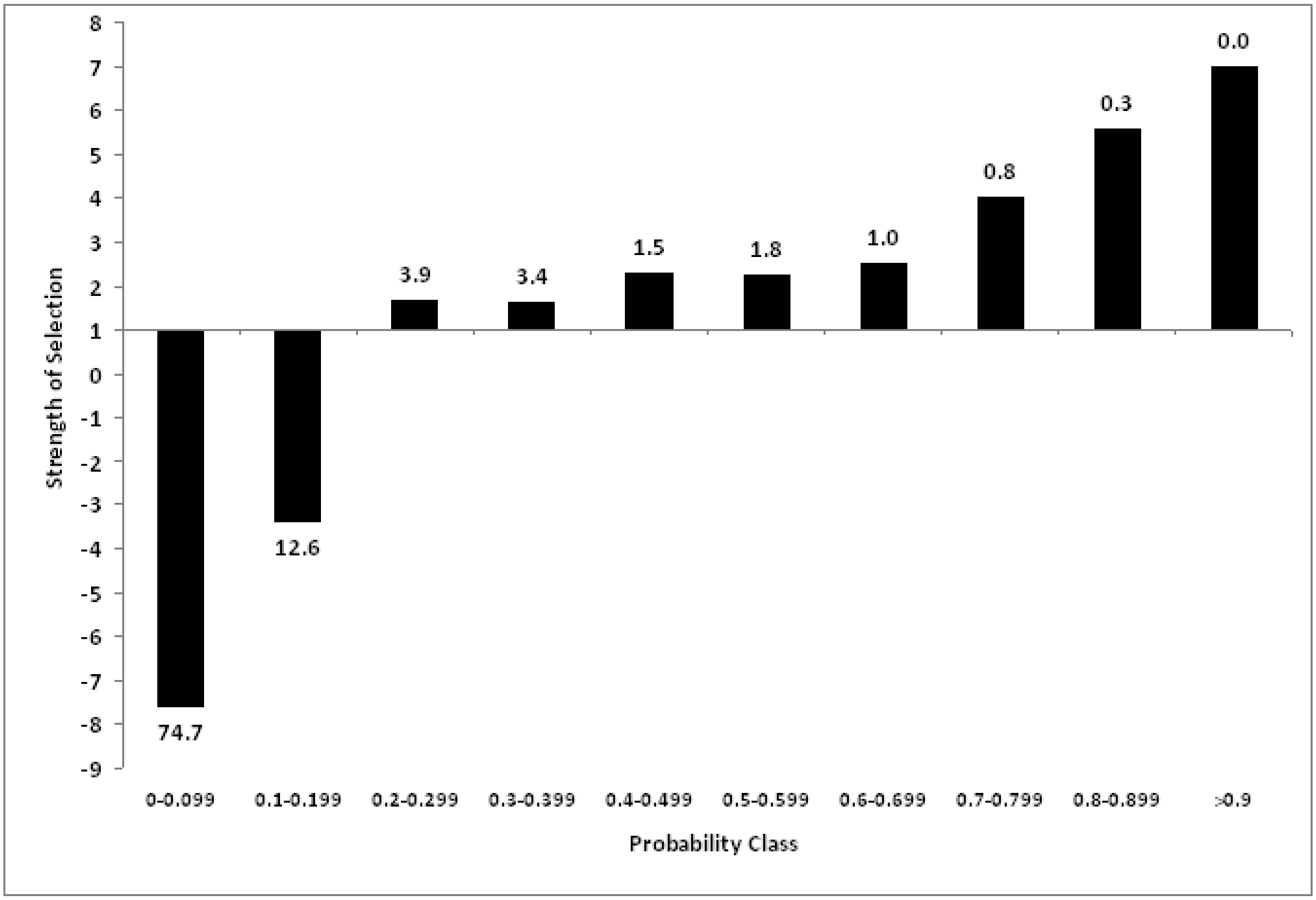

Figure 3. Strength of habitat selection by red tree voles on Federal land throughout their range in Oregon and percentage of FIA plots in DPS within each Probability Class. Probability Classes are the probability of occurrence of red tree vole nests in a plot with certain habitat characteristics, with probabilities divided into 10 equally sized groups. Bars represent the strength of selection by red tree voles for each Probability Class, with values less than 1 (below the line) indicating habitat avoidance and values greater than 1 (above the line) indicating habitat selection within a specific Probability Class. The gradient in strength of selection exhibited by red tree voles ranged from strongest selection for the highest Probability Classes (bars to the right of the graph) to strong selection against the lowest Probability Classes (bars to the left of the graph). The number at the end of each bar is the percentage of plots within the DPS within that Probability Class.

Spies et al. (2007b, entire) modeled red tree vole habitat in the Coast Range Physiographic Province of Oregon (physiographic provinces are geographic divisions of areas of distinctive topography and geomorphic structure). Their results indicated that tree vole habitat currently makes up almost 50 percent of the province, with just under half of that habitat occurring on private lands (Spies et al. 2007a, p. 10, Figure 2). While this assessment of the current condition of tree vole habitat in coastal Oregon differs from Dunk (2009, entire), we believe Dunk to be a more accurate description of red tree vole habitat in the DPS and rely more heavily on that work for the following reasons. Dunks analysis is specific to the DPS, whereas the Coast Range Physiographic Province, which includes the DPS, covers an additional 1.8 million ac (728,000 ha) extending south of the DPS. Second, Spies et al. (2007b, p. 51, Appendix D) assessed tree vole habitat by developing habitat capability index models that reflect habitat characteristics important for survival and reproduction based on literature and expert opinion. The variables they used were restricted to existing geographic information system layers that could be projected into the future using forest dynamics models. They were not able to empirically verify their red tree vole habitat capability index model with independent data, although it was reviewed by two published experts. Dunks analysis (2009, entire) relied on the red tree vole habitat model described in Dunk and Hawley (2009, entire), which was empirically developed based on presence or absence of red tree vole nests in FIA plots on Federal lands throughout most of the tree vole range. Dunk (2009, entire) then applied that model to FIA plots across all ownerships within the DPS to describe current tree vole habitat distribution based on existing field data.

As noted earlier, although red tree voles are widely considered habitat specialists strongly associated with older forests, they may also be found in younger stands (Maser 1966, pp. 216-217; Thompson and Diller 2002, p. 95; Swingle and Forsman 2009, pp. 278, 284; Price et al. 2015, pp. 45-46; Forsman et al. undated, p. 5), which are much more abundant in the DPS. Although some have suggested that these young forests may be population sinks (Carey 1991, p. 34), the role of younger stands in tree vole population dynamics is unclear. Tree voles in young stands may represent attempts of emigrants to establish territories, or may be residual populations that tolerate habitat disturbance (USDA and USDI 2000a, p. 378). It is possible that some young stands are on unique microsites where tree voles are able to reinvade and persist in the developing stands (Forsman 2010, pers. comm.). Younger stands may also be important for allowing dispersal and short-term persistence in landscapes where older forests are either isolated in remnant patches or have been largely eliminated (Swingle 2005, p. 94). The presence of individuals within a particular habitat condition does not necessarily mean the habitat is optimal, and individuals may be driven into marginal habitat if it is all that is available (Gaston et al. 2002, p. 374). Swingle and Forsman (2009, entire) found radio-collared tree voles in young stands throughout the year, but occupancy of younger stands appears to be short-term or intermittent (USDA and USDI 2000a, p. 378; Diller 2010, pers. comm.; Hopkins 2010, pers. comm.).

There are few data on survival of tree voles in younger stands. The only study conducted to date suggested no difference in annual survival of tree voles in young (22 to 55 years) and old (110 to 260 years) stands, but the authors cautioned that their sample sizes were small and had low power to detect effects (Swingle 2005, p. 64; Forsman and Swingle 2009, pers. comm.). Thinning younger stands occupied by tree voles can reduce or eliminate voles from these stands (Biswell 2010, pers. comm.; Swingle 2010, pers. comm.; Wilson and Forsman 2012, p. 185), and Carey (1991, p. 8) suggests activities that result in rapidly developing (changing, unstable) younger forests are a limiting factor for red tree voles. Conversely, when vole nests classified as occupied (based on indication of activity such as presence of fresh green resin ducts) were protected with a 10-ac (4-ha) buffer zone during thinning treatments, Hopkins (2010, pers. comm.) continued to find signs of occupancy at these nests post-treatment, although signs of occupancy were intermittent through time. However, Hopkins (2010, pers. comm.) results are subject to the limitations of using the presence or absence of green resin ducts to determine the activity status of nests (see the beginning of Factor A, above). Red tree voles may ultimately come back to a treated stand, but how long it will be after the treatment before the stand is reoccupied is unknown. If and when tree voles return likely depends on a multitude of factors including magnitude, intensity and frequency of the treatment within the stand, type and amount of structure left after treatment (e.g., large trees), and whether or not there is a refugium or source population nearby that is available to supply voles for recruitment when the treated stand becomes suitable again (Biswell 2010, pers. comm.; Forsman 2010, pers. comm.; Hopkins 2010, pers. comm.; Swingle 2010, pers. comm.). Thus, while the value of younger stands as suitable habitat to voles is unclear, they may provide some value in otherwise denuded landscapes, and thinning treatments in these stands have the potential to further reduce vole numbers, especially if thinning design does not account for structural features and the connectivity of those features that are important to red tree voles (Swingle and Forsman 2009, p. 284; Wilson and Forsman 2013, pp. 84-86). Swingle (2005, pp. 78, 94), however, cautions against using the occasional presence of tree voles in young forests to refute the importance of old forest habitats to tree voles. Price et al. (2015, pp. 45-46) suggest that unequal detection probabilities may bias the proportion of nests found in older versus younger forests; they further noted that the vast majority of young stands examined in their study area were devoid of red tree voles.

In summary, whether red tree voles in younger forests can persist over long periods or are ephemeral populations that contribute little to overall long-term population viability remains unknown at this time (USDA and USDI 2007, p. 291). However, the recent work of Dunk (2009, entire) and Dunk and Hawley (2009, entire) indicate that red tree voles display strong selection for forests with late-successional structural characteristics.

Although the role of younger forest is uncertain, based on our evaluation of the best available scientific data, as described above, we conclude that older forests are necessary habitat for red tree voles and that younger stands will rarely substitute as habitat in the complete or near absence of older stands. While some State land and much of the Federal ownership is managed for development or maintenance of late-successional habitat or old-forest structure conditions, full development of this habitat has yet to occur (see below). In addition, thinning activities designed to achieve these objectives can reduce or eliminate tree voles from these stands. The ongoing management of forests in most of the North Oregon Coast DPS for the purposes of timber production contributes to the threat of habitat modification for the red tree vole, as forest habitats are prevented from attaining the high-quality older forest characteristics naturally selected by red tree voles and are maintained in a low-quality condition for red tree voles in the DPS. Our evaluation of the remaining older forest patches within the DPS indicate they are likely insufficient to sustain red tree voles over the long term due to their relatively small size and isolated nature (see Factor E, below).

Projected Trends in Red Tree Vole Habitat

Implementing current land management policies in the Coast Range Province is projected to provide an increase (approximately 20 percent) in red tree vole habitat over the next 100 years, primarily on Federal and State lands (Spies et al. 2007b, p. 53). Vegetation simulations indicate that private industrial timber lands will generally be dominated by open and small- and medium-sized conifer forests. Old forest structure and habitat will strongly increase on Federal and State lands, and large, continuous blocks of forest will increase primarily on Forest Service and State lands (Johnson et al. 2007, pp. 41-42). The estimate of older forests on State lands, however, may be a substantial overestimate because the analysis was not able to fully incorporate the complexity of the State forest management plan (Johnson et al. 2007, p. 43; Spies et al. 2007a, p. 11). In addition, ODF has since reduced the targeted level of old forest to be developed in northwestern Oregon forests (ODF 2001, p. 4-48; 2010b, p. 4-48). Yet even with the projected overall increase, the amounts of old forest will not approach historical levels estimated to have occurred over the last 1,000 years in the Coast Range Province (Spies et al. 2007a, pp. 10-11), and these blocks of restored older forest will continue to be separated by forests in earlier seral stages on private lands. Although restoration of Oregon Coast Range forests to historical levels of older forest conditions is not requisite for the conservation of red tree voles, we have no evidence to suggest the present dearth of suitable habitat for the red tree vole will be alleviated by the modest projected increases in older forest conditions on Federal and State lands within the DPS. Even though the amount of suitable habitat on public lands may eventually increase, these patches of suitable habitat will remain fragmented due to landownership patterns and associated differences in management within the DPS. Furthermore, the time required for stand development to achieve these improved conditions (100 years) is substantial; whether these gradual changes will occur in time to benefit the red tree vole in the North Oregon Coast DPS is unknown. However, we anticipate that any patches of suitable habitat that may be found on public lands within the DPS 100 years from now will continue to be fragmented and isolated, due to the management practices on intervening private lands that inhibit connectivity. Thus, although projected future conditions represent a potential improvement in suitable habitat for the red tree vole, the time lag in achieving these conditions and the fragmented nature of public lands in the northern Oregon Coast Range suggests that a potential gain of 20 percent more suitable habitat 100 years from now is likely not sufficient to offset the loss, modification, and fragmentation of habitat and isolation of populations that collectively pose an immediate threat to the red tree vole in the DPS.

Loss of forest land to development is projected to occur in 10 percent of the Coast Range Province, and would most likely occur on non-industrial private lands, near large metropolitan areas, and along the Willamette Valley margin (Johnson et al. 2007, p. 41; Spies et al. 2007a, p. 11). Although timber production in the Coast Range has shifted by ownership class, declining on Federal lands and increasing on private lands, overall production is projected to stay at recent harvest levels. Actual production may result in levels higher than projected because harvest levels estimated for private industrial timberland were conservative (Johnson et al. 2007, pp. 42-43) and timber production on State lands may be underestimated by 20 to 50 percent (Johnson et al. 2007, p. 43). Johnson et al. (2007, pp. 45-46) described several key uncertainties that were not accounted for in their projections of future trends in the Coast Range that could potentially affect their results. These uncertainties include: effects of climate change; recently adopted initiatives that may result in an increased loss of forest land to cities, towns, and small developments; a possible decrease in global competitiveness of the Coast Range forest industry; sales of industrial forests to Timber Management Investment Organizations that may result in a shift of land use to other types of development; the effects of Swiss needle cast on the future of plantation forestry; and effects of wildfire. Most of these scenarios would result in a loss of existing or potential tree vole habitat, contributing further to the present loss, modification, fragmentation, and isolation of habitat for the red tree vole within the DPS, although the magnitude of that loss is uncertain.

In conclusion, while modest increases in tree vole habitat are expected to occur in the Oregon Coast Range over the next century, they are limited primarily to Federal lands and, to some lesser degree, State lands, although the amount of older forests on State lands may be an overestimate. As described above, the time lag in achieving this potential increase in suitable habitat and the fragmented nature of public lands, especially those Federal lands with the highest quality habitats, suggests that any future gains are likely not sufficient to offset the present threat of habitat loss, modification, or fragmentation, and its ongoing contribution to the isolation of red tree voles in the DPS. Tree voles are considered uncommon and sparsely distributed north of U.S. Highway 20 (USDA and USDI 2007, pp. 289, 294), where 92 percent of the State and County ownership, and 77 percent of the private ownership within the DPS occurs (Figure 2). Given the relatively little amount of Federal land in this area and the projected trends for non-Federal lands, tree vole status and distribution in this portion of the DPS is not likely to substantially improve.

Summary of Factor A

The North Oregon Coast DPS of the red tree vole is threatened by the effects of both past and current habitat loss, including ongoing habitat modification that results in the maintenance of poor quality forest habitats and insufficient older forest habitats, addressed here, and habitat fragmentation and isolation of small populations, addressed under Factor E. Nearly 80 percent of the DPS is in State, County, and private ownership, and most of the forested areas are managed for timber production. Ongoing timber harvest on a short rotation schedule over most of this area maintains these forests in a low-quality habitat condition, preventing these younger stands from developing the older forest conditions most suitable for red tree voles. Although the role of younger forest stands is not entirely clear, we conclude the preponderance of the best available information suggests that red tree voles are habitat specialists strongly associated with unfragmented forests that exhibit late-successional characteristics; while younger forests may play an important role as interim or dispersal habitat, older forests are required to maintain viable populations of red tree voles over the long term. The ongoing management of forests in the North Oregon Coast DPS for the purposes of timber harvest thus contributes to the threat of habitat modification for the red tree vole, as forest habitats are prevented from attaining the high-quality older forest characteristics naturally selected by red tree voles and are maintained in a low-quality condition for red tree voles in the DPS.

Factors that hinder the development and maturation of younger forest stages into late-successional forest conditions contribute to the ongoing modification of suitable habitat and maintain the present condition of insufficient remaining older forest habitat for the red tree vole in the DPS. The persistence and development of high-quality tree vole habitat over the next century under existing management policies is likely to occur primarily on Federal lands, and to a lesser degree on State lands. However, as Federal lands make up less than a quarter of the area of the DPS, even with eventually improved conditions, suitable red tree vole habitat will remain restricted in size, in distribution, and in a fragmented, isolated condition for the foreseeable future. In the interim, thinning activities designed to accelerate the development of late-successional forest structure conducive to tree vole habitat may reduce or eliminate local populations for an undetermined amount of time.

Declines in the amount of older forest within the Coast Range Province are unprecedented in recent history (Wimberly et al. 2000, pp. 176-178). This decline has translated into substantial habitat loss for red tree voles, with only 11 percent (approximately 425,000 ac (173,000 ha)) of the nearly 4 million ac (1.6 million ha) within the DPS boundary assumed to be potentially suitable habitat (Dunk 2009, p. 5). Most of this suitable habitat is restricted to Federal lands that lie in two discontinuous clusters within the DPS. State and private lands, which collectively comprise nearly 80 percent of the DPS area, provide very little suitable habitat; roughly 9 percent of the State and private lands, combined, are considered potentially suitable habitat for red tree voles (Dunk 2009, pp. 6-7).

Nearly 90 percent of the DPS is currently in a habitat condition avoided by red tree voles, and only 0.3 percent of the DPS is in a condition for which red tree voles show strong selection for nesting (Dunk 2009, p. 7). Given that nest presence does not correspond exactly with vole presence, and that the FIA sampling design may include habitat that is unavailable to tree voles, this is likely an overestimate of potential red tree vole habitat. Although Federal lands offer some protection and management of red tree vole habitat, indications are that there may not be enough habitat in suitable condition to support red tree voles north of U.S. Highway 20. In this area of the DPS, Federal land is limited, connectivity between blocks of Federal land is restricted, and there are few known vole sites currently available to potentially recolonize habitat as it matures into suitable condition. Surrounding private timber lands are not expected to provide long-term tree vole habitat over the next century, and projections of suitable tree vole habitat on State land may be overestimates.

Conclusion for Factor A

Recent surveys at locations within the DPS where red tree voles were readily captured 30 to 40 years ago have resulted in significantly fewer voles captured per unit of survey effort compared to historical collections. This suggests that tree vole numbers have declined in many areas where voles were once readily obtained by early collectors (Forsman 2009, pers. comm.). Although standardized quantitative data are not available to rigorously assess population trends of red tree voles, we believe it is reasonable to conclude that, based on information from retrospective surveys of historical vole collection sites, red tree voles have declined in the DPS and no longer occur, or are now scarce, in areas where they were once relatively abundant. Loss of habitat in the DPS, primarily due to timber harvest, has been substantial and has probably been a significant contributor to the apparent decline in tree vole numbers. Current management practices for timber production, particularly on the State, and privately-owned lands that comprise the vast majority of the DPS, keep the majority of the remaining forest habitat from maturing and developing the late-successional characteristics that comprise highly suitable habitat for red tree voles. Current management for timber harvest thereby contributes to the ongoing modification of tree vole habitat, as well as the fragmented and isolated condition of the remaining limited older forest habitat for the species. The remaining older forest patches are likely too small and isolated to maintain red tree voles over the long term (see Factor E, below). The biology and life history of red tree voles render the species especially vulnerable to habitat fragmentation, isolation, and chance environmental disturbances such as large-scale fires that could reasonably be expected to occur within the DPS within the foreseeable future (Martin and McComb 2003, p. 583; also addressed in Factor E). Based on our evaluation of present and likely future habitat conditions, we conclude that the ongoing effects of the destruction, modification, and curtailment of its habitat, in conjunction with other factors described in this finding, pose a significant threat to the persistence of the North Oregon Coast DPS of the red tree vole.

We have evaluated the best available scientific and commercial data on the present or threatened destruction, modification, or curtailment of the habitat or range of the North Oregon Coast DPS of the red tree vole, and determined that this factor poses a significant threat to the continued existence of the North Oregon Coast DPS of the red tree vole, when we consider this factor in concert with the other factors impacting the DPS.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

We are not aware of any information that indicates that overutilization for commercial, recreational, scientific, or educational purposes threatens the continued existence of the North Oregon Coast DPS of the red tree vole and have determined that this factor does not pose a significant threat to the viability of the North Oregon Coast DPS of the red tree vole.

C. Disease or predation:

We are not aware of any information that indicates that disease threatens the North Oregon Coast DPS of the red tree vole, now or in the foreseeable future. With respect to predation, the red tree vole is prey for a variety of mammals and birds (see above under Mortality), although voles persist in many areas despite the large numbers of predators (Forsman et al. 2004, p. 300). However, barred owls have recently expanded into the Pacific Northwest and are a relatively new predator of red tree voles. Red tree voles, among other mammal species, are an important prey item of barred owls, particularly during fall and winter (Wiens 2012, pp. 39, 44). While the varied diet of the barred owl, compared with the spotted owl, may potentially limit their pressure as predators on tree voles, the fact that their territories outnumber those of spotted owls in the southern portion of the DPS by a greater than 4.5:1 ratio (Wiens 2012, p. 45) increases that pressure. However, it is inconclusive as to what degree the invasion of the barred owl may have changed predation pressure on the red tree vole. To answer that question, one would have to consider not only the direct effect of barred owl predation on tree voles, but the effect that barred owls have on other tree vole predators. For example, barred owls are known to displace northern spotted owls from their home ranges, and negative relationships between barred owl occurrence and spotted owl survival, fecundity, and population trends are evident (see Wiens 2012, pp. 3 and 4 for summary). In addition, barred owls also forage on other predators of red tree voles, such as weasels, Steller's jays, and other owl species (Wiens 2012, pp. 137-138). Therefore, while the invasion of barred owls remains a concern, we cannot draw any conclusions as to the impact of barred owls on red tree voles in the DPS at this time.

Conclusion for Factor C

While predators undoubtedly have some effect on annual fluctuations in tree vole numbers, there is no evidence to suggest that changes in predation rates have caused or will cause long-term declines in tree vole numbers. Tree voles are exposed to a variety of predators and as a prey species they have adapted traits that reduce their exposure and vulnerability to predation; examples include cryptic coloration, leaping from trees when pursued (Maser et al. 1981, p. 204), and minimizing the duration of individual foraging bouts outside of the nest (Forsman et al. 2009a, p. 269). While habitat alterations may affect the exposure and vulnerability of tree voles to predators (see above under Mortality), predators themselves do not appear to be a principal threat affecting long-term trends in red tree vole numbers. However, the invasion of the barred owl is likely altering the predation pressures on tree voles to an unknown degree, and it remains to be seen to what extent these pressures will affect tree vole populations in the long term. We therefore conclude that the continued existence of the red tree vole in the North Oregon Coast DPS is not threatened by disease or predation at this time. However, it is too early to tell whether changes in predation pressures as a result of the barred owl invasion will be substantial enough to result in a significant threat to red tree voles.

We have evaluated the best available scientific and commercial data on the effects of disease or predation on the North Oregon Coast DPS of the red tree vole, and determined that this factor does not pose a significant threat to the viability of the North Oregon Coast DPS of the red tree vole at this time.

D. The inadequacy of existing regulatory mechanisms:

The red tree vole is not listed on Oregon's Threatened and Endangered Species List. It is, however, identified by the Oregon Department of Fish and Wildlife (ODFW) as a sensitive species in the Oregon Coast Range, categorized as vulnerable (ODFW 2008, p. 13). Although the intent of the sensitive species list is to prevent species from declining to the point of qualifying as threatened or endangered, this list is not used as a candidate list for species to be considered for listing under the Oregon Threatened and Endangered Species rules. Rather than serve a regulatory function, the sensitive species list identifies species for managers and the public to prioritize conservation actions and encourage voluntary actions to improve the species status. The vulnerable category is assigned to those species facing one or more threats to their populations or habitats. Vulnerable species are not currently imperiled with extirpation from a specific geographic area or the state but could become so with continued or increased threats to populations or habitats (ODFW 2008, p. 2). The red tree vole is also listed in the Oregon Conservation Strategy with specific actions believed necessary for conservation (ODFW 2006, p. 322).

Timber harvest has been identified as the primary cause of vegetation change and loss of red tree vole habitat in the Oregon Coast Range Province (Wimberly and Ohmann 2004, pp. 643-644) (see Factor A discussion, above). Although most of the losses of late-successional forest conditions occurred historically, these losses, combined with current management of younger forests on both private and public lands, contribute to the ongoing modification, curtailment, fragmentation, and isolation of habitat for the red tree vole in the DPS. The inadequacy of existing regulatory mechanisms in regard to timber harvest contributes to these threats. Regulations for timber harvest differ among land ownerships and are explained in separate sections below.

Regulatory Mechanisms on Private Land

Private lands make up 62 percent of the DPS, and over 75 percent of timber harvest in the Coast Range Province is expected to come from private forest lands (Johnson et al. 2007, entire; Spies et al. 2007b, p. 50). The Oregon Forest Practice Administrative Rules and Forest Practices Act (OARs) (ODF 2010a, entire) apply on all private and State-owned lands in Oregon, regulating activities that are part of the commercial growing and harvesting of trees, including timber harvesting, road construction and maintenance, slash treatment, reforestation, and pesticide and fertilizer use. The OARs provide additional guidelines intended for protection of soils, water, fish and wildlife habitat, and specific wildlife species while engaging in tree growing and harvesting activities. The red tree vole is not one of the specific species provided for in the OARs, and we are not aware of any proactive management for tree voles on private timberlands in Oregon.

Per the Oregon Revised Statute, an average of five snags or green trees per ha (two per ac) greater than 9 m (30 ft) tall and 28 cm (11 in) diameter are required to be left in harvest units greater than 10 ha (25 ac) (ORS 527.676); up to half of these trees may be hardwoods. Retention buffers are required around northern spotted owl nest sites (28 ha (70 ac) with suitable habitat) (OAR 629-665-0210), bald eagle nest sites (100 m (330 ft)) (OAR 629-665-0220,), bald eagle roost sites (100 m (300 ft)) (OAR 629-665-0230), and great blue heron nest sites (91 m (300 ft)) (OAR 629-665-0120). In addition, foraging trees used by bald eagles (OAR 629-665-0240) and osprey nest trees and associated key nest site trees (OAR 629-665-0110) are also protected from timber harvest. In all cases, protections of these sites are lifted when the site is no longer considered active (OAR 629-665-0010).

Within the Coast Range, small perennial streams that are neither fish bearing nor a domestic water source have no tree retention requirements. With respect to all other perennial streams, no harvest is allowed within 6 m (20 ft). In addition, riparian management areas are established around all fish-bearing streams and large or medium non-fish-bearing streams; their distances range from 6 to 30 m (20 to 100 ft) beyond the stream, depending on the stream size and fish-bearing status. Within these riparian management areas, from 4 to 28 m^2 (40 to 300 ft^2) of basal area must be retained for every 305 m (1,000 ft) of stream; basal area retention levels depend on stream size, fish presence, and type of harvest (OAR 629-640-0100 through 629-640-0400). Trees within the no-harvest 6-m (20-ft) buffer count towards these retention requirements. To meet the basal area requirement within the riparian management areas of large and medium streams, a minimum number of live conifers must be retained to meet shade requirements. Depending on stream size and fish-bearing status, live conifer retention requirements range from 10 to 40 per 305 m (1,000 ft) of stream, with a minimum size of either 20 or 28 cm (8 or 11 in) dbh. If the basal area requirements are still not met with the minimum conifer retention, the remainder can be met with trees greater than 15 cm (6 in); a portion of this retention can be met with snags and hardwoods (excluding red alder (Alnus rubra)). For all streams where the pre-harvest basal area of the riparian area is less than the targeted retention level, timber harvest may still occur (section 6 of OAR 629-640-0100 and section 7 of OAR 629-640-0200). In addition, basal area credits may be granted, upon approval, for other stream enhancements, such as placing downed logs in streams to enhance large woody debris conditions (OAR 629-640-0110). Thus, while basal area credits may produce in-stream enhancements, they simultaneously reduce potential arboreal habitat for red tree voles.

Given the extensive network of streams within the Coast Range, riparian management areas appear to have potential in providing connectivity habitat for red tree voles between large patches of remnant older forest stands. However, given the minimum tree retention sizes and numbers prescribed under the OARs, we believe them to be insufficient to provide adequate habitat to sustain populations of red tree voles, and likely not sufficient to provide connectivity between large patches of remnant older forest stands. As an example, the streamside rules providing the most protection apply around fish-bearing streams (sections 5-7 of OAR 629-640-100). Although these sections require retention of 40 live conifer trees per 305 m (1,000 ft) along large streams, and 30 live conifer trees along medium streams, these trees need only be 28 cm (11 in) dbh for larger streams and 20 cm (8 in) dbh for medium streams to count toward these requirements. Although these regulatory requirements are stated as minimums, they potentially allow for conditions such that the remaining trees will likely be far smaller than those generally utilized by red tree voles, and the remaining trees may be relatively widely dispersed along the riparian corridor, thereby impeding arboreal movement. Furthermore, the purpose of tree retention in riparian management areas is to retain stream shade, and retaining a minimum number of live conifers is designed to distribute that shade along the stream reach by retaining more, smaller trees to meet the basal area requirements rather than concentrate the targeted basal area into a few large trees. Consequently, there is little incentive to retain any larger trees within the riparian management areas.

In general, biological corridors are believed to be beneficial for the conservation of fragmented populations by allowing for genetic interchange and potential recolonization (e.g., Bennett 1990, entire; Fahrig and Merriam 1994, p. 51; Rosenberg et al. 1997, p. 677); however, possible disadvantages may include potential increases in predation, parasitism, and invasion of interior habitats by introduced species (e.g., Wilcove et al. 1986, pp. 249-250; Simberloff and Cox 1987, pp. 66-67; Yahner 1988, p. 337; Simberloff et al. 1992, p. 498). Long, narrow strips of habitat suffer from a high ratio of edge to interior, resulting in edge effects such as altered microclimates and potentially increased vulnerability to generalist predators (Yahner 1988, p. 337; Saunders et al. 1991, pp. 20-22; Chen et al. 1993, p. 220). In old-growth Douglas-fir forests, altered environmental conditions may extend up to 137 m (450 ft) from the forest edge, to the extent that patches less than 10 ha (25 ac) in size provide essentially no forest interior habitat (Chen et al. 1992, p. 395).

The successful use of corridors to maintain regional populations is highly species-specific (Rosenberg et al. 1997, p. 683; Debinski and Holt 2000, p. 351) and depends on the spatial configuration of the remaining habitat, the quality of the corridor habitat, and the habitat specificity and dispersal ability of the species in question (Henein and Merriam 1990, p. 157; Fahrig and Merriam 1994, p. 53; With and Crist 1995, entire; Rosenberg et al. 1997, entire). In general, habitat specialists with limited dispersal capabilities, such as the red tree vole, have a lower critical threshold for responding to fragmented habitats; such species may experience the environment as functionally disconnected even when their preferred habitat still comprises nearly half of the landscape (With and Crist 1995, p. 2452; Pardini et al. 2010, p. 6). Reduced survival probability for animals moving through linear corridors of habitat may potentially be offset by large numbers of dispersers, but for animals with relatively low reproductive rates and low mobility, such as the red tree vole, survival probability may be compromised under such conditions (Martin and McComb 2003, p. 578). Poor-quality habitat conditions for red tree voles in riparian management areas, such as from reduced canopy cover, may reduce their probability of survival in moving through such a patch (Martin and McComb 2003, p. 577). For example, there is some evidence that small mammals may experience increased risk and local extinction events of predation in narrow corridors or isolated fragments of habitat (e.g., Henderson et al. 1985, p. 103; Mahan and Yahner 1999, pp. 1995-1996). Although riparian buffers are frequently suggested as potential corridors for dispersal, Soulé and Simberloff (1986, pp. 33-34) specifically suggest that forest interior species such as the red tree vole would likely avoid using such areas for movement between remaining patches of conifer forest. Observations that red tree voles are now apparently absent from forest stands where they historically occurred indicate riparian management areas are likely not functioning as successful corridors for dispersal and recolonization by red tree voles in the DPS.

Although the OARs do not specifically provide protection for red tree voles, some protections may be afforded to individuals that are incidentally found within buffers retained for sensitive wildlife sites. However, such scattered remnants of possible habitat are unlikely to protect viable populations due to their small size and fragmented and isolated nature. In addition, these protected areas can be logged if the site is no longer occupied by the target species. The short timber harvest rotations (e.g., in calculating its riparian rule standards, OARs assume 50-year rotations for even-aged stands, and 25-year entry intervals for uneven-aged management) in the surrounding landscape further limits the potential for a well-connected tree vole population. Although tree voles have been found in these younger stands, frequent thinning, larger harvest units, and the tendency for these large harvest units to aggregate into larger blocks of younger stands that are unlikely to develop into red tree vole habitat (Cohen et al. 2002, p. 131) decrease the likelihood that tree voles will persist on industrial private timber lands even with protections afforded to other species per the OARs. Therefore, based on the above assessment, we conclude that existing regulatory mechanisms on private land are inadequate to ameliorate the threat of habitat loss and fragmentation and provide for the conservation of the North Oregon Coast DPS of the red tree vole.

Summary of Regulatory Mechanisms on Private Land

Private lands comprise more than 60 percent of the DPS, and most of the projected future timber harvest in the Oregon Coast Range is anticipated to come from these lands. The Oregon Forest Practices Administrative Rules and Forest Practices Act (OARs) provide the current regulatory mechanism for timber harvest on private lands within the DPS. The stated goal of the OARs is to provide for commercial growing and harvesting of trees. The OARs additionally provide guidelines intended to protect soils, water, and fish and wildlife habitat, including protection of specific wildlife species, during the course of these activities. The red tree vole is not one of the specific species protected by the OARs, and due to its relatively specialized habitat requirements and limited dispersal capability, provisions intended to conserve habitat for other wildlife species are likely inadequate to provide for the conservation of the red tree vole. Despite the incidental benefits provided by protective measures for aquatic resources and other wildlife, management under this regulatory mechanism results in much of what little habitat remains for the red tree vole being continually modified such that insufficient high-quality habitat (well-connected stands with older forest characteristics) is maintained, and remnant older forest patches remain fragmented and isolated due to intensive management in the surrounding landscape. Furthermore, the intensive industrial management accompanied by short rotations prevents younger forests from ever developing into older forest habitats selected by tree voles. We therefore conclude that existing regulatory mechanisms on private land are inadequate to provide for the conservation of the North Oregon Coast DPS of the red tree vole, as they contribute to threats of habitat destruction, modification, or curtailment under Factor A, as well as the threats of habitat fragmentation and isolation of small populations under Factor E.

Regulatory Mechanisms on State Land

State lands make up 16 percent of the DPS, totaling just over 242,800 ha (600,000 ac). Although there are some scattered State parks located primarily along the coastal headlands, virtually all of the State ownership in the DPS is land managed by the ODF in the Tillamook and Clatsop State Forests, as well as other scattered parcels of State forest land in the southern half of the DPS. State forest lands are to be actively managed, assuring a sustainable timber supply and revenue to the State, counties, and local taxing districts (ODF 2010b, pp. 3-2, 3-4 to 3-5). Annual timber harvests projected over the next decade for each of the three State Forest districts within the DPS sum to 422,000 m3 (181 million board ft) (ODF 2009, p. 59; 2011a, p. 74; 2011b, p. 69). Harvest intensities (annual harvest per area of landbase) differ by district; harvest intensity for the Tillamook District, which comprises half of the State Forest ownership within the DPS, is projected at 2.5 m3 per ha (188 board ft per ac) per year. Volume per unit area conversions are approximate and use the formula 1 cubic m per ha = 75 board ft per ac as found in Husch et al. (2003, p. 219). The Astoria and Forest Grove Districts project substantially higher harvest intensities of 7.01 and 7.07 m3 per ha (526 and 530 board ft per ac) per year, respectively. Areas used to calculate harvest intensity may include lands that are not capable of producing forest, so intensities may be somewhat underestimated.

The overarching statutory goal for management of State forest lands is to provide, healthy, productive, and sustainable forest ecosystems that over time and across the landscape provide a full range of social, economic, and environmental benefits to the people of Oregon (ODF 2010b, p. 3-12). Common School Forest Lands comprise 3 percent of the northwestern Oregon State Forests, and they are to be managed to maximize income to the Common School Fund (ODF

2010b, p. 3-2). To the extent that it is compatible with these statute-based goals, wildlife resources are to be managed in a regional context, providing habitats that contribute to maintaining or enhancing native wildlife populations at self-sustaining levels (ODF 2010b, pp. 3-12, 3-14).

The Northwestern Oregon State Forest Management Plan provides management direction for the State Forests within the DPS (ODF 2010b, p. 1-3). There is no specific direction in the ODF northwestern forest management plan recommending or requiring surveys or protecting tree vole sites if they are found on State lands. ODF personnel are recording tree vole nest locations as ancillary information collected during climbing inspections of marbled murrelet (Brachyramphus marmoratus) nests (Gostin 2009, pers. comm.), but are not implementing site-specific management or conservation measures to known sites beyond recording the nests.

Red tree voles are, however, one of several species of concern identified by ODF. Species of concern strategies specific to red tree voles entail the development of anchor habitats (ODF 2010b, pp. 4-82 to 4-83, E-42). Anchor habitats are, intended to provide locales where populations will receive a higher level of protection in the short-term until additional suitable habitat is created across the landscape (ODF 2010b, p. 4-82). They are not intended to be permanent reserves. Terrestrial anchor habitats are intended to benefit species associated with older forest and interior habitat conditions, and management within them will promote the development of complex forest structure (ODF 2010b, pp. 4-82 to 4-83). Within the State Forests in the DPS, there are 13 terrestrial anchor habitat areas totaling 17,536 ha (43,332 ac) (Palazzotto 2015, pers. comm.).

Although the OARs apply on all State lands, the ODF may develop additional site-specific management regulations that are potentially more stringent than those set forth in the OARs. With respect to management around marbled murrelet and northern spotted owl sites, ODF exceeds the protections called for by the OARs. Spotted owl sites are protected by a 28-ha (70-ac) core of the best available habitat around the nest, maintenance of 202 ha (500 ac) of suitable habitat within 1.1 km (0.7 mi) of the nest, and 40 percent of habitat within 2.4 km (1.5 mi) of the nest (ODF 2013a). Additional protections are applied on the Tillamook and Clatsop State Forest, where a 101-ha (250-ac) core is designated (ODF 2013b). Currently there are 15 owl sites on ODF State Forests within the DPS and another 12 in adjacent lands wherein buffers from these sites overlap onto ODF ownership, translating to approximately 21,368 ha (52,800 ac) of ODF-managed lands in these sites (Palazzotto 2015, pers. comm.). Marbled murrelet management areas (MMMA) are established around marbled murrelet occupied sites (ODF 2013c) to minimize the risk of violating the section 9 take prohibitions of the Endangered Species Act. Suitable habitat within an operational activity is surveyed for murrelets and occupied habitat is designated as an MMMA, along with a 100-m (328-ft) buffer around the suitable habitat. As of 2015, there were 72 MMMAs within the DPS totaling 3,798 ha (9,384 ac) (Palazzotto 2015, pers. comm.). Per the recent murrelet policy guidance, MMMAs designated prior to 2013 will be reevaluated to align with increased protections provided in the current policy. ODF also applies the OARs protection buffers for bald eagle nests and roosts, and great blue heron nests (see Regulatory Mechanisms on Private Land above).

ODF regulations for fish-bearing streams provide a 52-m (170-ft) buffer on each side, with no harvest within 7.6 m (25 ft), management for mature forest (basal area of 20 m2 (220 ft2) of trees greater than 28 cm (11 in) dbh) between 7.6 and 30 m (25 and 100 ft) of the stream, and retention of 25 to 113 conifers and snags per ha (10 to 45per ac) between 30 and 52 m (100 and 170 ft) of the stream (ODF 2010b, p. J-7). Management standards for large and medium streams that are not fish-bearing are similar to fish-bearing streams except that conifer and snag retention levels between 30 to 52 m (100 and 170 ft) from the stream are reduced to 25 per ha (10 per ac) (ODF 2010b, p. J-8). Management standards for small, perennial, non-fish-bearing streams, as well as intermittent streams considered high energy reaches (ODF 2010b, pp. J-9 J-10), apply to at least 75 percent of the stream reach and include no harvest within 7.6 m (25 ft), retain 38 to 63 conifer trees and snags per ha (15 to 25 per ac) between 7.6 to 30 m (25 to 100 ft) of the stream, and retain 0 to 25 conifer trees and snags per ha (0 to 10 per ac) between 30 to 52 m (100 to 170 ft). Additional management standards also apply within 30 m (100 ft) of intermittent streams (ODF 2010b, p. J-10). Within harvest units, all snags are to be retained, and green tree retention must average 13 per ha (5 per ac) (ODF 2010b, pp. 4-53 to 4-54). Although riparian retention levels on ODF lands are larger than what is required on private lands, they still allow for a reduction in existing habitat suitability for red tree voles, with minimum retention levels not meeting tree vole habitat requirements due to reduced stand densities and lack of crown continuity.

State forests are managed for specific amounts of forest structural stages. The objective is to develop 15 to 25 percent of the landscape into older forest structure (81 cm (32 in) minimum diameter trees, multiple canopy layers, diverse structural features, and diverse understory) and 15 to 25 percent into layered structure (two canopy layers, diverse multi-species shrub layering, and greater than 46 cm (18 in) diameter trees mixed with younger trees) over the long term (ODF 2010b, p. 4-48). Attainment of these objectives would benefit the red tree vole; however, this is not the current condition of State forests within the DPS, and these desired future conditions are not projected to be reached for at least 70 years (ODF 2010b, p I-13). At present, only about 1 percent of the State forests in northwestern Oregon are currently in older forest structure and 12 percent are in a layered structure condition (ODF 2003, pp. 4, 12; ODF 2012, pp. 3, 24; ODF 2009, pp. 4, 21; ODF 2011a, pp. 11, 25, 28; ODF 2011b, pp. 9, 28). While 13 percent of the State forests are in a complex structure category (old forest and layered forest structure, combined), only a small subset of this likely provides tree vole habitat given that only 5 percent of the State land is considered actual red tree vole habitat (Dunk 2009, pp. 5, 7).

Given the description provided (ODF 2010b, p. 4-48), we estimate the older forest structure condition as defined by the ODF would generally provide red tree vole habitat. However, only a portion of the layered structure condition appears to be suitable tree vole habitat, and that is likely to be stands with more complexity that are closer in condition to that found in stands classed as old forest structure. According to Dunk (2009, pp. 4, 7), stands that currently meet tree vole habitat requirements on State lands are limited to 5 percent of the State ownership and, given such a low proportion, are most likely isolated. Furthermore, the direction is to actively manage these landscapes to meet the targeted forest structure stages via thinning activities that promote desired structural features. The use of thinning activities to create stands that may be suitable habitat for red tree voles has not been tested; to the extent we can develop the appropriate structure and conditions in the long term, such treatments in the surrounding landscape over the short term likely further limits the potential for a well-connected tree vole population in the interim. Meanwhile, tree voles would have to persist in these small patches of suitable habitat for decades before more suitable habitat developed.

The effect of thinning treatments on red tree voles has not been quantified, but it appears to reduce their abundance, most noticeably by reducing canopy cover that increases exposure to predators, reducing canopy connectivity, and restricting nesting substrates (Wilson and Forsman 2013, p. 83). Younger stands may be important for allowing dispersal and short-term persistence of tree voles in landscapes where older forests are either isolated in remnant patches or have been largely eliminated (Swingle 2005, p. 94). Thinning these younger stands, while designed to develop late-successional habitat characteristics in the long term, has the potential to degrade or remove tree vole habitat in the short term, especially if thinning design does not account for structural features and the connectivity of those features that are important to red tree voles (Swingle and Forsman 2009, p. 284; Wilson and Forsman 2013, pp.. 84-86).

As reported in USDA and USDI (2002, p. 13), although old, inactive red tree vole nests have been found in thinned stands and shelterwood treatments, no occupied nests have been found, suggesting that red tree voles are susceptible to stand level disturbances that alter the canopy layer and may cause sites to become unsuitable. Biswell (2010, pers. comm.) and Swingle (2010, pers. comm.) have also observed reduction in numbers or elimination of red tree voles from stands that have been thinned. Hopkins (2010, pers. comm.) found that buffering nests with a 4-ha (10-ac) buffer would result in the presence of nests post-thinning, but he did not attempt to verify vole occupancy through visual observations of voles.

Although State Forest lands are managing part of their landbase to retain and develop some older forest habitat, the lack of survey and protection mechanisms to protect existing tree vole sites, combined with the limited availability of current suitable habitat and intensity of harvest and thinning activities between protected areas, leads us to conclude that existing regulatory mechanisms on State lands are inadequate to ameliorate the threat of habitat loss and fragmentation and provide for the conservation of the North Oregon Coast DPS of the red tree vole.

Summary of Regulatory Mechanisms on State Land

As discussed above under Regulatory Mechanisms on Private Land, there may be some ancillary benefits to red tree voles from actions taken to protect other wildlife species. In addition to the OARs requirement to provide buffers to protect certain wildlife species, ODF provides additional buffers for spotted owls and marbled murrelets, as well as additional retention blocks in the form of terrestrial anchor habitats scattered throughout its property. While these areas provide for some habitat retention, some are likely too small and most too isolated to provide for a species with limited dispersal ability, such as the red tree vole. Furthermore, without pre-project surveys for voles, the species will need to serendipitously be in these retention blocks to be afforded any protections. Occupied vole sites outside these areas would be lost with any timber harvest activity.

This precludes the opportunity to potentially reduce isolation and provide for additional retention blocks elsewhere on the landscape where tree voles may actually be present, thereby improving their dispersal potential.

Because of the small amounts (13 percent) of complex forest habitat (1 percent older forest and 12 percent layered forest structure) currently available on State lands throughout the DPS, there is limited ability to maintain persistent populations of red tree voles on this ownership. Also, not all areas of the combined structure categories may provide tree vole habitat, considering that empirical evidence indicates only 5 percent of the State ownership within the DPS is currently considered tree vole habitat (Dunk 2009, pp. 5, 7). State Forest Management Plans call for developing more of these older habitats, but these conditions are not expected to be reached for at least 70 years. Moreover, the use of thinning activities to create stands that may be suitable habitat for red tree voles has not been tested; to the extent we can develop the appropriate structure and conditions, it is reasonable to conclude that much of the 15 to 25 percent of the landscape targeted as older forest structural condition may eventually be suitable tree vole habitat. However, as described above, based on the currently observed proportion of suitable red tree vole habitat relative to layered forest conditions, it is likely only some undetermined portion of the 15 to 25 percent of the landscape targeted as layered forest condition may provide suitable habitat. Finally, thinning activities designed to meet these long-term structure targets may place additional limitations on the ability of tree vole populations to be well connected over the next 70 years.

Although the State does manage their forests with an eventual increase in older forest conditions as a goal, most of the State lands within the DPS are managed for some level of continuing timber harvest. The loss and modification of red tree vole habitat on State lands, compounded by isolation of existing habitat as a result of timber harvest, continues under existing regulatory mechanisms. In addition, there are no mechanisms in place to protect existing occupied tree vole sites outside of retention areas. We therefore conclude that existing regulatory mechanisms on State land are inadequate to provide for the conservation of the North Oregon Coast DPS of the red tree vole, as they contribute to threats of habitat destruction, modification, or curtailment under Factor A, as well as the threats of habitat fragmentation and isolation of small populations under Factor E.

Regulatory Mechanisms on Federal Land

Federal lands comprise 22 percent of the DPS (344,400 ha (851,000 ac)) and are concentrated in two separate areas. The southernmost portion lies between U.S. Highway 20 and the Siuslaw River, and makes up roughly two-thirds of the Federal lands within the DPS (Figure 2). The remaining Federal ownership, although more fragmented and dispersed than the southern portion in terms of ownership pattern, is generally located between Lincoln City and Tillamook, with a few scattered parcels of BLM land in Columbia and Washington counties. The Siuslaw National Forest comprises 41 percent of the Federal land in the DPS. The Salem and Eugene BLM Districts and a small portion of the Roseburg BLM District make up the remainder of the Federal ownership. Federal lands have been managed under the NWFP (USDA and USDI 1994, entire), although there is past and ongoing litigation that has, and will continue to, affect management planning for BLM within the DPS (see below). Implementation of the NWFP resulted in an 80 to 90 percent reduction of timber harvests from Federal lands in the Coast Range compared to levels in the 1980s (Spies et al. 2007b, p. 50). Approximate timber harvests projected for the next two years on the Federal ownership in the North Oregon Coast DPS sum to 231,000 cubic m (99 million board ft) on average per year (Herrin 2011, pers. comm.; Nowack 2011, pers. comm.; Wilson 2011, pers. comm.). This may include harvest in some areas within an administrative unit that is not encompassed by the DPS, primarily that portion of the Siuslaw National Forest that lies south of the Siuslaw River (approximately 15 percent of the forest area). Currently, all the harvest on Federal land in the North Oregon Coast DPS occurs as thinning. Harvest intensity (annual harvest per area of landbase) differs by administrative unit and ranges from 0.88 cubic m per ha (66 board ft per ac) per year on the Siuslaw National Forest to 2.05 cubic m per ha (154 board ft per ac) per year on that portion of the Eugene BLM District within the DPS. Areas used to calculate harvest intensity may include land that is not capable of producing forest, so harvest intensities may be somewhat underestimated.

Within the DPS, BLM has operated under two different management plans over the past several years. On December 30, 2008, BLM published Records of Decision (ROD) for the Western Oregon Plan Revisions (WOPR), which revised the Resource Management Plans for the BLM units in western Oregon, including those units within the DPS. The WOPR meant that BLM would no longer be managing their land under the standards and guidelines of BLMs 1995 RODs and Resource Management Plans, which had adopted the NWFP. On July 16, 2009, the Acting Assistant Secretary for Lands and Minerals administratively withdrew the WOPR RODs. The administrative withdrawal of WOPR was challenged in court (Douglas Timber Operators, Inc. v. Salazar, 09-1704 JDB (D.D.C.). On March 31, 2011, the United States District Court for the District of Columbia vacated and remanded the administrative withdrawal of the WOPR RODs, effectively reinstating the WOPR RODs as the operative Resource Management Plan for BLM lands within the DPS. The analysis for Factor D in the 12-month finding designating the red tree vole as a candidate species (October 13, 2011, 76 FR 63720) was done using the 2008 WOPR ROD as the land management direction for BLM. However, on May 16, 2012, the U.S. District Court, District of Oregon (Pacific Rivers Council et al. v. Shepard (No. 3:11-cv-442-HU) (D. Or.)) vacated the 2008 ROD/Resource Management Plans for western Oregon BLM districts and reinstated BLM's 1995 RODs and Resource Management Plans. Thus, the western Oregon BLM Districts have reverted back to these NWFP-based RODs as the official land use plan of record. This Factor D analysis has been updated from the original 12-month finding based on this change in BLM management planning. In addition, there remains ongoing litigation, the result of which could affect future BLM management (e.g., AFRC v. Salazar-DOI/Locke, Case No. 1:11-cv-01174 (D.D.C.; Swanson Group et al. v. Salazar et al., Case No. 1:10-cv-01843 D.D.C.)). Finally, the BLM is beginning another revision of their resource management plans (BLM 2012, entire), considering alternatives that would differ from their current management under the NWFP. They have completed scoping and plan to release a final ROD in late 2015.

Of the Federal lands in the DPS, 51 percent are managed solely as LSRs, and 29 percent are managed as an AMA, which includes additional LSR management in portions of the AMA (see below). The primary management objectives in LSRs are to protect and enhance late-successional forest conditions (USDA and USDI 1994, p. C-11). Although forest structure can vary widely with vegetation type, disturbance regime, and developmental stage, in Douglas-fir stands of western Oregon, 80 years of age is generally considered the point at which stands can begin to develop the structural complexity that is of value to late-successional species (e.g., canopy differentiation and multiple canopy layers; understory development; large limbs; large snags and logs; tree decay and deformities in the form of hollow trees, broken tops, large cavities; and epicormic branching) (USDA and USDI 1994, pp. B-2 through B-7). Thinning is allowed in LSRs if needed to create and maintain late-successional forest conditions. Thinning is allowed in stands up to 80 years old, except for the Northern Coast AMA, where it is allowed in stands up to 110 years (USDA and USDI 1994, p. C-12). Salvage is allowed in LSRs subject to standards and guidelines to protect surviving trees and retain adequate snags and coarse woody debris, among other things, and is intended to prevent negative effects on late-successional habitat (USDA and USDI 1994, pp. C-13 through C-16).

The emphasis of the Northern Coast Range AMA is to restore and maintain late-successional forest habitat consistent with marbled murrelet guidelines (USDA and USDI 1994, p. D-15) through developing and testing new approaches that integrate ecological, economic, and other social objectives. Although 29 percent of the Federal land in the DPS is allocated as AMA, 20 percent of Federal land is managed as LSR within the AMA, meaning that LSR standards and guidelines are to be followed unless reconsidered as part of the AMA plan. The current AMA plan has retained the original NWFP standards and guidelines for LSRs, so in effect 71 percent of the Federal ownership is currently managed as LSR (51 percent LSR, 20 percent AMA managed as LSR). The one difference in LSR management within the AMA as compared to the rest of the NWFP area is that thinning is allowed in stands up to 110 years of age in the AMA, as described above.

Of the 20 percent of Federal lands not designated as LSR or AMA in the DPS, 16 percent is classified as Matrix, where timber harvest in addition to thinning is permitted (e.g., regeneration harvest such as clearcuts). The remaining 4 percent of lands in the DPS under Federal ownership are in Congressional Reserves or Administratively Withdrawn Areas under special management and not available for timber harvest. Because of the stream densities in the Coast Range, much of the Matrix allocation is overlain by riparian reserves that can be anywhere from 150 to 500 ft (76 to 152 m) wide on each side of the stream, depending on the waterbody and site condition (USDA and USDI 1994b, pp. C-30 through C-31; Davis 2009, pers. comm.). Timber harvest is not allowed in riparian reserves except for silvicultural activities that are consistent with Aquatic Conservation Strategy objectives (USDA and USDI 1994, pp. C-30 through C-31). Protections for occupied marbled murrelet sites and other species also overlay Matrix lands, further reducing the area available for timber harvest. For example, between riparian reserves and other protections required by the NWFP, only 3 percent of the Siuslaw National Forest is available for timber harvest other than thinning treatments designed to meet ecological objectives (Davis 2009, pers. comm.). Although clearcuts and other regeneration harvests within the Matrix are allowed under the NWFP, Federal land managers within the DPS are limiting their timber harvests within the Matrix to thinning (Herrin 2011, pers. comm.; Nowack 2011, pers. comm.; Wilson 2011, pers. comm.).

Under the Survey and Manage standards and guidelines of the NWFP, surveys and subsequent management are required for multiple species, including the red tree vole, prior to certain habitat-disturbing activities (USDA and USDI 2001, pp. 10-11, 49 of Standards and Guidelines). Habitat-disturbing activities that do not require pre-project surveys, known as the Pechman exemptions (Northwest Ecosystem Alliance v. Rey, Case No. 04-844-MJP (W.D. Wash.)), include: 1) thinning in stands younger than 80 years old; 2) replacing or removing culverts; 3) improving riparian and stream habitat; and 4) using prescribed fire to treat hazardous fuels. Surveys for and subsequent management of red tree voles are only required in high-priority sites and the Federal agencies have developed a process for establishing high-priority sites (USDA and USDI 2003, entire; 2006, entire). Within a 80,130 ha (198,000 ac) pilot area within the southernmost portion of the DPS (primarily located within the Siuslaw River drainage), tree vole sites may be considered non-high-priority sites depending on the amount of reserve land allocation in the watershed, habitat quality, number of active vole nests detected in survey areas, and the total survey effort (USDA and USDI 2003, entire). Outside of the pilot area, non-high-priority sites can be designated on a project-specific basis with local interagency concurrence (USDA and USDI 2006, entire).

The BLM and Forest Service have made several attempts to revise or remove the Survey and Manage standards and guidelines (e.g., USDA 2007, entire; USDI 2007, entire), and have endured multiple legal challenges; (e.g., Conservation Northwest v. Rey, Case No. C- 08-1067-JCC (W.D. Wash.); Conservation Council v. Sherman, 2013 U.S. App. LEXIS 8396 (9th Cir. 2013)). However, the requirements for surveying and managing for red tree vole sites that are high priority, with the exceptions noted above, have remained intact (USDA 2014, entire; USDI 2014a, entire; USDI 2014b, entire)

Although federally managed lands are expected to provide for large, well-distributed populations of red tree voles throughout most of their range, the northern Oregon Coast Range north of Highway 20 within the DPS is an exception. For this area, despite the majority of the Federal land being managed as LSRs, the Final Environmental Impact Statement analyzing the effects of discontinuing the NWFP Survey and Manage program concluded that regardless of the tree voles status as a Survey and Manage species, the combination of small amounts of Federal land, limited connectivity between these lands, and few known vole sites would result in habitat insufficient to support stable populations of red tree voles north of Highway 20 (USDA and USDI 2007, pp. 291-292). Federal lands provide more habitat for red tree voles than other ownerships in the DPS and have land allocations, such as LSRs, that require management to maintain and restore late-successional conditions that are more suitable as red tree vole habitat. However, the limited amount of Federal lands in the DPS restricts red tree vole distribution and magnifies the effect of habitat loss occurring from stochastic events, further limiting the red tree voles ability to persist in an area or recolonize new sites (see Factors A and E).

Thinning treatments are allowed in LSRs up to a certain stand age. Although tree voles tend to select older forest stand, younger stands may be important for allowing dispersal and short-term persistence of tree voles in landscapes where older forests are either isolated in remnant patches or have been largely eliminated (Swingle 2005, p. 94). Thinning these younger stands, while designed to develop late-successional habitat characteristics in the long term, has the potential to degrade or remove tree vole habitat in the short term, especially if treatments do not account for structural features (e.g., nest substrates, cover from predators) and the connectivity of those features that are important to red tree voles (Swingle and Forsman 2009, p. 284; Wilson and Forsman 2013, pp. 83-86). As reported in USDA and USDI (2002, p. 13), although old, inactive red tree vole nests have been found in thinned stands and shelterwood treatments, no occupied nests have been found, suggesting that red tree voles are susceptible to stand-level disturbances that alter the canopy layer and may cause sites to become unsuitable. Biswell (2010, pers. comm.) and Swingle (2010, pers. comm.) have also observed reduction in numbers or elimination of red tree voles from stands that have been thinned. Hopkins (2010, pers. comm.) found that buffering nests with a 10-ac (4-ha) buffer would result in the presence of nests post-thinning, but he did not attempt to verify vole occupancy through visual observations of voles.

Red tree voles are afforded more protection on Federal lands than on State Forest and private lands within the DPS. Before commencing timber harvest activities (except for thinning activities in stands under 80 years old), projects must be surveyed for tree voles and high priority sites protected. Thirty percent of the Federal ownership is currently considered tree vole habitat, and 75 percent of the Federal ownership is in a land allocation that either precludes timber harvest or only allows silvicultural treatments designed to develop late-successional conditions. Thus, most of the Federal landbase should develop into conditions suitable as red tree vole habitat. In addition, conifer-dominated forests in riparian reserves that cross Matrix land allocation may provide additional future habitat. Thinning activities designed to develop older forest conditions in the long term may limit the dispersal capability and connectivity of local tree vole populations in the short term. Except for the limited amount and isolated nature of Federal lands north of Highway 20, federally managed lands are expected to provide for large, well-distributed populations of red tree voles throughout the rest of their range within the DPS. Based on the above assessment, we conclude that existing regulatory mechanisms on Federal land are adequate to provide for the conservation of the North Oregon Coast DPS of the red tree vole.

Summary of Regulatory Mechanisms on Federal Land

Although they comprise less than one-quarter of the land area within the DPS, Federal lands provide the majority of remaining high-quality, older forest habitat for red tree voles within the DPS. The implementation of the NWFP in 1994 led to a decrease in timber harvest on Federal lands, and today the majority of these lands within the DPS are managed to maintain or restore late-successional forest conditions. Although some level of timber harvest continues on these Federal lands, particularly in the Matrix allocation, it affects only a tiny portion of the DPS; in addition, all current and planned harvests within the Matrix allocation are limited to thinning treatments. Some degree of thinning also occurs within LSRs in the DPS, but if managed according to the standards and guidelines of the NWFP, and if such thinning does not exceed the current rates, the effects of such treatments on red tree voles are believed to be relatively minor. Implementation of the Survey and Manage standards and guidelines of the NWFP provides additional contributions to the conservation of the red tree vole and its habitat within the DPS through the requirement to survey and manage for high-priority sites. We therefore consider existing regulatory mechanisms adequate to provide for the conservation of the red tree vole on Federal lands where they occur within the DPS. In the unlikely event the Forest Service and BLM do not or cannot implement these measures, protections for the red tree vole would be reduced on

Federal lands, subsequently reducing the adequacy of regulatory mechanisms on these lands. In addition, the insufficient quantity of Federal lands and their distribution within the DPS contribute to the threat of habitat fragmentation, isolation, and potential extirpation of local populations due to stochastic events, as detailed in Factor E, below.

Conclusion for Factor D

Existing regulatory mechanisms are inadequate to provide for the protection and management of red tree voles on the 78 percent of the DPS made up of non-Federal (private and State) lands. The State of Oregon has regulatory mechanisms in place on private and State lands designed to provide for commercial timber harvest on relatively short rotation schedules, while simultaneously conserving habitat and protecting specific wildlife species during the course of activities associated with timber growth and harvest. The red tree vole is not one of those specific species targeted for protection under the OARs, and due to its relatively specialized habitat requirements and limited dispersal abilities, many of the guidelines intended to conserve other wildlife species are not sufficient to provide adequate habitat for the red tree vole. Although some individual red tree voles may enjoy incidental benefits if they are located within tree retention or buffer areas, these small buffer areas are not expected to provide for long-term persistence of red tree vole populations given their isolated nature and the allowance for removal of some buffers if the target species is no longer present. In addition, short rotations and intensive management of the surrounding stands will not likely develop or retain the structural features advantageous to red tree voles, thus contributing to the threat of habitat modification and maintaining the isolation of any tree voles that may be present in these areas. Timber harvest rates are expected to continue at current levels on private lands. Protection measures in addition to the OARs are provided on State Forest lands, allowing for more retained and protected areas on the landscape. State Forests are also being managed to increase the amount of structurally complex forests. However, loss and modification of red tree vole habitat on private and State lands as a result of timber harvest continues under existing regulatory mechanisms. Furthermore, there are no mechanisms in place to protect existing occupied tree vole sites outside of retention areas.

Although Federal lands offer some habitat protection and management, there may not be enough habitat in a condition to provide for the red tree vole north of U.S. Highway 20 where Federal land is limited. There is restricted connectivity among blocks of Federal land in this area, and few known vole sites currently available to recolonize habitat. Given the protections provided by the Survey and Manage standards and guidelines, the low level of timber harvest compared to other ownerships, and the projected management of over 75 percent of their landbase as late-successional condition, current regulatory mechanisms appear to be adequate on Federal lands. Because we find that existing regulatory mechanisms are not adequate to protect habitat for tree voles on the nearly 80 percent of the DPS that is made up of State or private lands, we conclude that overall, existing regulatory mechanisms are not adequate to protect the DPS from the threats discussed under Factors A and E and, in conjunction with these additional factors, pose a significant threat to the persistence of the North Oregon Coast DPS of the red tree vole.

We have evaluated the best available scientific and commercial data on the inadequacy of existing regulatory mechanisms, and determined that this factor poses a significant threat to the viability of the North Oregon Coast DPS of the red tree vole, when we consider this factor in concert with the other factors impacting the DPS.

E. Other natural or manmade factors affecting its continued existence:

Fragmentation and Isolation of Older Forest Habitats

Tree voles in the northern Oregon Coast Range evolved in vast, well-distributed expanses of primarily late-successional forest. By 1936, the amount of large-conifer forest was already below the historical range of 52 to 85 percent of the Coast Range estimated to contain late-successional forest (greater than 80 years old) over the past 1,000 years (Wimberly et al. 2000, p. 175; Wimberly and Ohmann 2004, p. 642). In 1936, extensive patches of large-conifer Douglas-fir forest connected much of the central and southern portions of the Coast Range Province. In the northern quarter of the province, patches of large Douglas-fir combined with large spruce-hemlock forest and intermingled with large patches of open and very young stands (Wimberly and Ohmann 2004, pp. 635, 639). Most of those open and young stands encompassed the 121,000 ha (300,000 ac) that had recently burned in the 1933 Tillamook fire. By 1996, large blocks of the remaining large-conifer forest were restricted to Federal and State lands in the central portion of the Coast Range Province, having been eliminated from most private lands (Wimberly and Ohmann 2004, p. 635). Elsewhere, large-conifer forests were primarily isolated in scattered fragments on public land. The 1936 area of the Coast Range Province covered by large Douglas-fir (5,315 km2 (2,052 mi2)) and large spruce-hemlock (891 km2 (344 mi2)) cover types declined by 1996, primarily as a result of timber harvest, resulting in a 58 percent reduction in the total area of large-conifer forest. Conversely, the combined area of small Douglas-fir and spruce-hemlock forests increased by 87 percent (Wimberly and Ohmann 2004, pp. 639-641).

Not only have amounts of older forest decreased, but the spatial distribution of those forests has changed. Prior to European settlement, vegetation simulations indicate that mature (80 to 200 years) and old-growth forest (greater than 200 years) patches had the highest densities of all successional stages within the Coast Range Province. In addition, old-growth patches were large, ranging from 2,100 to 8,500 km^2 (810 to 3,280 mi^2), with a median of 4,300 km^2 (1,660 mi^2), while patches of less than 80-year-old forests were generally less than 2,000 km^2 (770 mi^2) (Wimberly 2002, p. 1322). In the Coast Range Province today, the largest old-growth patch is 6.5 km^2 (2.5 mi^2), while the largest patch of early-seral forest (less than 30 years old) is larger than 5,000 km^2 (1,900 mi^2), and the largest patch of 30 to 80-year-old forest is larger than 3,000 km^2 (1,150 mi^2) (Wimberly et al. 2004, p. 152).

There is little information on minimum stand sizes used by tree voles and a complete lack of information on how much habitat is needed to sustain tree vole populations (USDA and USDI 2000b, p. 7). In Polk and Tillamook counties, Hopkins (2010, pers. comm.) found vole nests in forest patches as small as 2 to 4 ha (5 to 10 ac) in the oldest (350 to 400 years), most structurally complex stands available. Huff et al. (1992, pp. 6-7) compiled data on actual red tree vole presence and found the mean age of stands in which tree voles were found in the Coast Range was 340 years and the minimum stand size was 30 ha (75 ac), with mean and median stand sizes of 192 and 129 ha (475 and 318 ac), respectively. Whether a minimum patch size of 2 to 4 ha (5 to 10 ac) or even 30 ha (75 ac) can sustain a population of red tree voles over the long term is unknown and is influenced by such things as habitat quality within and surrounding the stand, the position of the stand within the landscape, and the ability of individuals to move among stands (Huff et al. 1992, p. 7; Martin and McComb 2003, pp. 571-579).

However, in the absence of better information on the stand size needed to sustain tree vole populations (USDA and USDI 2000b, p. 7), we consider the 30-ha (75-ac) minimum patch size identified by Huff et al. (1992, pp. 6-7) the best available information to use for our analysis because it represents actual tree vole occurrence and not just presence of a nest. We used this patch size in an analysis to determine what proportion of late-successional and old-growth (LSOG) within the DPS comprises patches large enough to support tree voles, and how close individual patches are to other suitable patches. The LSOG database used was part of the NWFP effectiveness monitoring program (USDA/USDI 2010, unpublished data). We found that 59 percent of the area mapped as LSOG occurred in patches larger than 30 ha (75 ac). Extrapolated to Dunks (2009, p. 7) analysis, which shows only 11 percent of the DPS contains actual tree vole habitat (418,000 ac (169,165 ha)), we find the suitability potentially further reduced to only 99,807 ha (246,620 ac), or 6 percent of the DPS. This is consistent with Dunk (2009, p. 9), who noted that his figure did not take into account habitat fragmentation, connectivity, and metapopulation dynamics that may influence whether populations or individual tree voles could occur within his area of analysis.

It is important to note that even the forested areas identified as individual patches through a geographic information systems (GIS) program do not necessarily represent areas of forest with continuous canopy cover. Although these patches of forest are technically connected at some level, inspection of the data in our analysis reveal that they are for the most part highly porous and discontinuous, and we performed no analysis to filter out stands that may be so porous or discontinuous as to provide no interior habitat. Furthermore, the LSOG definition used as part of the NWFP monitoring program (mean tree dbh of 51 cm (20 in) or greater; canopy cover 10 percent or greater; all tree species included) can include stands that do not necessarily equate to red tree vole habitat and represents a substantial overestimate. For example, while the LSOG dataset identified 307,559 ha (759,968 ac) of LSOG within the DPS, Dunk (2009, pp. 4, 7) found red tree vole habitat to comprise approximately 172,000 ha (425,000 ac) of the DPS (see Continuing Modification and Current Condition of Red Tree Vole Habitat in Factor A, above). There are several reasons why the LSOG database overestimates red tree vole habitat. First, the dataset included stands with canopy cover as low as 10 percent, which is well below the minimum and mean canopy cover of 53 and 78 percent, respectively, for stands in which Swingle (2005, p. 39), as one example, found tree vole nests. The dataset also included hardwood species as part of the canopy cover component allowing for the possibility of LSOG patches comprising primarily hardwood stands with scattered large conifers. While tree voles have been found in mixed conifer/hardwood stands, their exclusive diet of conifer needles would limit the habitat capability of stands that are primarily hardwood. Therefore, our analysis of remaining older forest patches in the DPS provides an overestimate in terms of remaining potential tree vole habitat, given that the LSOG data used provide a liberal characterization of tree vole habitat. Furthermore, the GIS pixel aggregation done as part of our patch analysis likely characterized some of the data as patches that would in reality be too porous to function as tree vole habitat, increasing the potential for overestimation. Applying the proportion of this LSOG data set that meets the minimum forest patch size to the area of DPS considered suitable tree vole habitat (Dunk 2009, p. 7), an analysis considered a likely overestimate of tree vole occupancy (see Factor A. Continuing Modification and Current Condition of Red Tree Vole Habitat, above), we find only 6 percent of the DPS may be in suitable habitat that is of a large enough patch size to sustain tree voles. This suggests that the remaining potentially suitable habitat for tree voles is highly fragmented, which further lessens the probability of long-term persistence of red tree voles under current conditions in the DPS.

In simulated pre-European settlement forests of the Coast Range Province, most forests less than 200 years old were within 1 km (0.4 mi) of an old-growth forest patch. This pattern has reversed, with a considerable increase in isolation of old-growth forest patches (Wimberly et al. 2004, p. 152). Our analysis of the LSOG forest data provided by the NWFP effectiveness monitoring program indicates that in the DPS, the average distance between LSOG forest patches greater than 30 ha (75 ac) in size was 532 m (1,745 ft). Larger patches greater than 202 ha (500 ac) in size were separated by 1,877 m (6,158 ft) on average. This increasing isolation of LSOG forest patches due to maintenance of younger stands in the intervening areas poses a threat to the red tree vole, as the dispersal capability of this species is limited. As noted earlier, the greatest known dispersal distance for an individual red tree vole is 340 m (1,115 ft) (Biswell and Meslow, unpublished data referenced in USDA and USDI 2000b, p. 8), but shorter distances from 3 to 75 m (10 to 246 ft) appear to be more the norm for dispersing subadults (Swingle 2005, p. 63). The current average distance between patches of LSOG forest in the DPS thus exceeds the known maximum dispersal distances of red tree voles. A matrix of surrounding younger forest is not entirely inhospitable habitat for dispersing red tree voles, but survivorship in such habitats is likely reduced. Whether red tree voles can successfully disperse between remaining patches of fragmented habitat depends on their vagility and tolerance for the intervening matrix habitat (Pardini 2004, p. 2581).

Historically, dispersal between trees in areas of more contiguous older forest would not have been a limiting factor for red tree voles, but under the current conditions of fragmentation, the ability of individuals to disperse between patches of remaining high quality habitat is restricted. Limited dispersal can translate into a lack of sufficient gene flow to maintain diversity and evolutionary potential within the population, possible inbreeding depression, Allee effects (e.g., failure to locate a mate), and other problems (e.g., Soulé 1980, entire; Terborgh and Winter 1980, pp. 129-130; Shaffer 1981, p. 131; Gilpin and Soulé 1986, pp. 26-27; Lande 1988, pp. 1457-1458). The potential for the local loss of populations is high, as remnant habitat patches formerly occupied by tree voles may not be recolonized due to the distance between habitat fragments and the short-distance dispersal of the species, leading to local extirpation and further isolation of the remaining small populations, and possibly eventual extinction (see Isolation of Populations and Small Population Size, below). As noted above, although we do not have standardized, quantitative survey data, the fact that red tree voles are increasingly difficult to find and have apparently disappeared from some areas where they were formerly known to occur suggests that current habitat conditions are not conducive to the successful dispersal or maintenance of red tree vole populations within the DPS.

Highly suitable red tree vole habitat (that with the greatest strength of selection) is quite rare throughout the range of the red tree vole (Dunk and Hawley 2009, p. 632), and is even more restricted within the North Oregon Coast DPS (Dunk 2009, pp. 4-5). Moreover, large blocks of older forest (greater than 400 ha (1,000 ac)) are restricted primarily to Federal lands, with contiguous blocks separated by great distances (Moeur et al. 2005, p. 77). Fragmentation complicates habitat availability for red tree voles, which select for patches of large tree structure where fragmentation is minimized (Martin and McComb 2002, p. 262); having evolved in extensive areas of relatively more contiguous late-successional forest, tree voles are especially vulnerable to the negative effects of fragmentation and isolation due to their limited dispersal capability. Within the DPS, virtually all of the Federal land lies in two widely separated clusters (Figure 2). Much of the southern portion of the DPS, south of U.S. Highway 20, is Federal land, with the other cluster of Federal land lying north of Highway 20, mainly between Lincoln City and Tillamook. As most of the remaining high-quality habitat for red tree voles within the DPS is restricted to these two clusters of Federal lands, there is little redundancy for tree vole populations within the DPS, and loss of either cluster would result in the single remaining cluster and its associated tree vole population being highly vulnerable to extirpation through some stochastic event, such as wildfire. These two blocks of Federal ownership are separated by primarily private and some State lands. Except for a small patch of checkerboard BLM ownership in southeast Columbia and northeast Yamhill counties, along with a few small State parks, ownership north of Tillamook consists almost entirely of private timberland and lands managed by ODF (Tillamook and Clatsop State Forests).

Implementing current land management policies in the Coast Range is projected to provide a modest increase (approximately 20 percent) in red tree vole habitat over the next 100 years, primarily on public lands (Spies et al. 2007b, p. 53). However, red tree vole populations appear to be decreasing in the face of current threats to their habitat. Therefore, we conclude that this limited increase in suitable habitat that may develop on public lands over an extended length of time will not be sufficient to address the lack of connectivity that currently exists between Federal lands, due to land management practices on the intervening lands (USDA and USDI 2007, p. 291). Furthermore, small, isolated populations of tree voles may not be capable of persisting over the length of time required to benefit from the projected increase in suitable habitat, but may more likely be subject to local extirpations in the intervening time period. The Final Environmental Impact Statement analyzing the effects of discontinuing the NWFP Survey and Manage program concluded that the combination of small amounts of Federal land, limited connectivity between these lands, and few known vole sites north of Highway 20 would result in habitat insufficient to support stable populations of red tree voles (USDA and USDI 2007, pp. 291-292). The authors of the report further concluded that due to these vulnerabilities, every site is critical for persistence for the red tree vole in Oregon’s North Coast Range north of Highway 20 (USDA and USDI 2007, p. 292). Given the fragmented nature of Federal lands providing late-successional conditions in the DPS and the limited connectivity between these remaining blocks, it is unlikely that the small projected increase in suitable habitat that may develop over the next 100 years on Federal lands will be sufficient to offset the more immediate threats of habitat destruction, modification, and fragmentation that threaten the North Oregon Coast population of the red tree vole.

Summary of Fragmentation and Isolation of Older Forest Habitats

Red tree voles are considered habitat specialists and are strongly associated with large, relatively more contiguous areas of conifer forests with late-successional characteristics; they are not adapted to fragmented or patchy habitats (Martin and McComb 2002, p. 262). The older forest habitat associated with red tree voles has been significantly reduced through historical timber harvest, and as discussed under Factor A, above, ongoing management for timber production maintains much of the remaining older forest habitat in a fragmented and isolated condition, surrounded by younger forests of lower quality habitat for tree voles. We analyzed data compiled as part of the NWFP effectiveness monitoring program (USDA/USDI 2010, unpublished data) and found that of the remaining older forest within the DPS, 59 percent is in patches greater than 30 ha (75 ac), but these patches comprise only 6 percent of the entire DPS. The average distance between the remaining patches that are at least 30 ha (75 ac) in size exceeds the known dispersal distances of red tree voles. This suggests that red tree voles are unlikely to persist over the long term in most of the remaining patches of older forest habitats within the DPS, because most of them are likely too small or too isolated to support tree vole populations. Although the surrounding younger forests may serve as interim or dispersal habitat, the evidence suggests that such forest conditions are unlikely to support persistent populations of red tree voles. Furthermore, our evaluation suggests that the remaining older forest habitat for tree voles is highly fragmented, which further lessens the probability of long-term persistence of red tree voles under current conditions in the DPS due to the limited dispersal capability of the species, and other consequences of isolation (see Isolation of Populations and Small Population Size, below).

Most of the remaining high-quality habitat for red tree voles in the DPS is restricted to Federal lands; however, these lands make up only 22 percent of the area within the DPS, and they occur in two widely spaced clusters, one north of Highway 20 and one south of Highway 20. Thus, there is little redundancy for tree vole populations within the DPS, and loss of either cluster on Federal lands would result in the single remaining cluster and its associated tree vole population being highly vulnerable to extirpation or even extinction through some stochastic event, such as wildfire (see Climate Change, below). Under present conditions, the Federal lands north of Highway 20 are already considered insufficient to support stable populations of red tree voles (USDA and USDI 2007, pp. 291-292).

Under the current conditions of habitat fragmentation within the DPS, the ability of red tree voles to disperse between patches of remaining high-quality habitat are extremely restricted, and the evidence suggests that any remaining tree vole populations within the DPS are likely relatively small. The potential for the local loss of populations is therefore high, as remnant habitat patches formerly occupied by tree voles may not be recolonized due to the distance between habitat fragments and the short-distance dispersal capabilities of the species, leading to local extirpation and further isolation of the remaining small populations, and possibly eventual extinction (see Isolation of Populations and Small Population Size, below). Furthermore, ongoing timber harvest in surrounding areas of younger forests contributes to the threat of habitat fragmentation and isolation, as discussed above in Factors A and D. Therefore, based on the above evaluation, we conclude that the fragmentation and isolation of older forest habitats pose a significant threat to the North Oregon Coast DPS of the red tree vole.

Climate Change

General Impacts. Climate change presents substantial uncertainty regarding future vegetation and habitat conditions in the North Oregon Coast DPS. Reduction and isolation of red tree vole habitat has been identified as a substantial threat to their persistence. Changing climate could further reduce and restrict tree vole habitat in ways that are difficult to predict.

Globally, poleward and upward elevational shifts in the ranges of plant and animal species are being observed and evidence indicates recent warming is influencing this change in distribution (Parmesan 2006, pp. 648-649; Marris 2007, entire; Chen et al. 2011, entire; IPCC 2014, p. 51; Romero-Lankao et al. 2014, p. 1458). In North America, and specifically in the Pacific Northwest, effects of forest pathogens, insects, and fire on forests are expected to increase, resulting in an extended period of high fire risk and large increases in area burned (Karl et al. 2009, pp. 136-137; OCCRI 2010, pp. 16-18; Shafer et al. 2010, pp. 183-185; Mote et al. 2014, p. 495; Romero-Lankao et al. 2014, pp. 1459-1461). The pattern of higher summer temperatures and earlier spring snowmelt, leading to greater summer moisture deficits and consequent increased fire risk, has already been observed in the forests of the Pacific Northwest (Karl et al. 2009, p. 136). Ecosystem resilience is expected to be exceeded by the unprecedented combination of climate change, its associated disturbances, and other ecosystem pressures such as land-use change and resource over-exploitation (IPCC 2007, p. 11). These projections discussed above indicate further reduction and isolation of red tree vole habitat over the next century.

Red tree voles in the North Oregon Coast DPS cannot shift their range farther north due to the existing barrier of the Columbia River, which defines the northern boundary of their current and historical range. In addition, their range already occupies the summit of the Oregon Coast Range, so a shift to higher elevations is also not possible. Climate change assessments predict possible extinctions of such local populations if they cannot shift their ranges in response to environmental change (Karl et al. 2009, p. 137).

Increased Frequency and Magnitude of Wildfire due to Climate Change. In the western hemlock and Sitka spruce plant series that dominates the Coast Range, fires tend to be rare but are usually stand-replacing events when they take place, although low- and moderate-severity fires also occur (Impara 1997, p. 92). Sediment core data show mean fire return intervals of 230 to 240 years over the past 2,700 years (Long et al. 1998, p. 786; Long and Whitlock 2002, p. 223). Three large fires, ranging from 120,000 to 325,000 ha (300,000 to 800,000 ac), occurred in the DPS in the 1800s, in addition to the Tillamook fires of 1933-1951 (Morris 1934, pp. 317-322, 328; Pyne 1982, pp. 336-337; Agee 1993, p. 212; Wimberly et al. 2000, p. 172). Climate change, combined with Euro-American settlement, may have influenced the onset of large-scale fires (Weisberg and Swanson 2003, p. 25). Another complication in these wetter forests has been a pattern of multiple reburns that occurred, such as the Tillamook burns of 1933, 1939, 1945, and 1951. Reburns may or may not add large amounts of additional area to the original burn, but they have the potential to impede the development of the stand for decades, delaying the ultimate return to older forest habitat suitable for red tree voles (Agee 1993, p. 213). Forests in the Pacific Northwest face an increased risk of large-scale fires within the foreseeable future; under the conditions of anticipated climate change, the effects of forest pathogens and fire on forests are expected to increase, resulting in an extended period of high fire risk and large increases in area burned (Karl et al. 2009, pp. 136-137; Mote et al. 2014, p. 495; Romero-Lankao et al. 2014, pp. 1459-1461). Most recently, the Oregon Climate Change Research Institute predicted that large fires will become more common in the forests west of the Cascades, which includes the forests of the North Oregon Coast Range; estimated increases in regional forest areas burned over the next century ranged from 180 to 300 percent (OCCRI 2010, p. 16).

Considering that the majority of the remaining tree vole habitat in the DPS is limited to Federal land, which comprises a total of roughly 344,000 ha (850,000 ac) and is restricted to two separate clusters in the DPS, it is certainly possible to lose much of the Federal land in either of these blocks to a single stand-replacement fire, further limiting habitat and restricting the range of the tree vole in the DPS. Fire suppression organization and tactics have improved since the large fires of the last two centuries, resulting in a reduction in forest fires (Wimberly et al. 2004, p. 153); although Weisberg and Swanson (2003, p. 25) note that suppression success may have been influenced by the reduction in fuel accumulations accomplished by the previous extensive fires. Regardless, the intense, large, high-severity fires that can occur in the Coast Range are driven by severe weather events (droughts or east wind patterns) (Agee 1997, p. 154), conditions under which fire suppression is severely hampered at best and ineffectual at worst (Impara 1997, pp. 262-263). Although large fires occurred within the DPS historically, in the past there were many additional areas of older forest that were less isolated from other older forest stands and could serve as a population source or as refugia for tree voles displaced from forests that burned; under current conditions, there are few such refugia available (Wimberly 2002, p. 1322; Wimberly et al. 2004, p. 152) (see Modification of Oregon Coast Range Vegetation above). Given that we have evidence of past fires in the Coast Range that burned areas of up to 325,000 ha (800,000 ac), an amount roughly twice as large as either of the remaining clusters of Federal land within the DPS, and that projections under anticipated conditions of climate change point to the increased risk and magnitude of fire in this region (e.g., OCCRI 2010, p. 16), we believe it is reasonably likely that a single stand-replacing fire could occur within the foreseeable future that would eliminate much of the remaining suitable habitat for tree voles within the DPS.

Summary of Climate Change

The uncertainty in climate change models prevents a specific assessment of potential future threats to the North Oregon Coast DPS of the red tree vole as a consequence of projected warming trends and the various environmental and ecological changes associated with increasing temperatures. However, the direction of these future trends indicate that climate change will likely exacerbate some of the key threats to the DPS, such as an increased probability of large wildfires which may result in the further destruction, modification, fragmentation, and isolation of older forest habitats, and evidence suggests that such changes may already be occurring. High-quality habitat for red tree voles within the DPS is largely restricted to two clusters of Federal lands, and these areas are small enough that a single stand-replacing fire could potentially concentrate the remaining red tree voles to primarily a single population that would be highly vulnerable to extirpation or extinction from future stochastic events. Furthermore, red tree voles within the DPS are restricted in their ability to shift their range in response to changes that may take place as a consequence of climate change. We therefore conclude that the environmental effects resulting from climate change, by itself or in combination with other factors, exacerbate threats to the North Oregon Coast DPS of the red tree vole.

Swiss Needle Cast

A large-scale disturbance event currently ongoing in the Oregon Coast Range is the spread of Swiss needle cast, a foliage disease specific to Douglas-fir caused by the fungus Phaeocryptopus gaeumannii. It is typically found in Douglas-fir grown outside of its native range, but in western Oregon it is primarily found, and is more consistently severe, along the western slope of the central and northern Oregon Coast Range, which overlaps both the Sitka spruce and western hemlock plant series. Douglas-fir accounted for less than 20 percent of the forest composition prior to the 1940s in this portion of the Coast Range, but timber harvest and large-scale planting of Douglas-fir on cutover areas make it the dominant species today. The wetter, milder weather, combined with a uniform distribution of the host species, favors the fungus and helps spread the disease (Hansen et al. 2000, p. 777; Shaw 2008, pp. 1, 3). In Oregon, Swiss needle cast is currently limited to the western part of the state. It has affected about 405,000 ha (1 million ac), much of that in the northern and central Oregon Coast Range of the DPS. It is roughly estimated that about half of the land base is moderately afflicted by Swiss needle cast, and about 10 percent of the area is severely afflicted by this disease (Filip 2009, pers. comm.).

Swiss needle cast causes premature needle loss which, although rarely lethal, reduces tree growth rates by 20 to 55 percent (Shaw 2008, pp. 1-2; Maguire et al. 2011, p. 2074).Young Douglas-firs infected with the pathogen are not expected to outgrow the disease (Black et al. 2010, p. 1680) and may never develop the large structures that are integral features of older, structurally complex forests. Most of the research on this disease has occurred in managed plantations less than 40 years old (Shaw 2009, pers. comm.), although it is known to limit growth in established overstory trees greater than 100 years old, even within mixed-species stands (Black et al. 2010, p. 1680). Future steps needed to manage Swiss needle cast are unclear. Conflicting information exists as to whether fertilization alleviates or exacerbates disease severity (Mulvey et al. 2013, p. 156; Shaw et al. 2011, pp. 114-115). Thinning treatments to improve tree vigor in infected stands do not appear to significantly affect the disease severity (Mainwaring et al. 2005, p. 2402; Shaw et al. 2011, p. 116).

Given our current knowledge, a likely scenario in coastal stands dominated by infected Douglas-fir is that the non-host Sitka spruce and western hemlock will become the dominant cover, moving these sites closer to the historical species composition present before earlier forest management converted them to Douglas-fir (Filip 2009, pers. comm.). Where these non-host species are deficient or absent in infected stands, reestablishing them in the stand is the only known treatment certain to reduce the spread and extent of Swiss needle cast. There is still much uncertainty in our understanding of this pathogen to project future trends in vegetation. While it could result in a return of western hemlock and Sitka spruce that were removed as a result of conversion to Douglas-fir plantations, it will be decades before these stands develop into the older forest conditions suitable as high-quality red tree vole habitat. In addition, the commercial value of Douglas-fir timber is a major incentive to continue research to develop pathogen treatments that would allow continued existence of healthy Douglas-fir stands.

Projected effects of climate trends indicate a likely expansion of Swiss needle cast beyond the western Oregon Coast Range as a result of projected increases in spring precipitation and winter temperatures, increasing the disease pressure on Douglas-fir further inland, to the north, and higher in elevation (Stone et al. 2008, p. 175; Lee et al. 2013, p. 687). The extent of this expansion, however, has not been estimated. Furthermore, the intensity and frequency in coastal Oregon will vary, likely increasing in the coastal fog zone, and decreasing in areas where warm and dry summers already limit fungal spore germination (Lee et al. 2013, p. 687). The effects of Swiss needle cast on tree vole habitat would likely reduce Douglas-fir needles, a food source for those individuals who feed on Douglas-fir. The disease also presents a potential negative effect as a result of thinning the canopy cover through needle loss, reducing the value of these stands as hiding cover and thermal protection for tree voles. In that part of the tree vole range where their principle diet is Sitka spruce or western hemlock, one possible long-term beneficial effect of this pathogen is the potential restoration of these tree species into the forest canopy. However, the development of older stands containing these species will take decades as western hemlock and Sitka spruce return to these stands and develop the older forest characteristics conducive to red tree vole habitat.

Summary of Swiss Needle Cast

Swiss needle cast is a foliage disease specific to Douglas-fir, and is found in western Oregon along the western slope of the central and northern Oregon Coast Range. Some of the most severe infestations of Swiss needle cast occur in the Sitka spruce plant series, which is the plant series in the DPS where tree voles forage primarily on western hemlock and Sitka spruce. However, the disease also occurs in the western hemlock plant series on the western slope of the Oregon Coast Range, where most of the voles that forage on Douglas-fir tend to occur. While the disease may ultimately improve foraging sources for some red tree voles over the long term, it may remove forage for others. In addition, Swiss needle cast may affect forest characteristics in mixed species stands that affect tree voles and are unrelated to foraging, such as reducing canopy closure and structural components that may provide hiding cover and thermal protection. The current footprint of Swiss needle cast infection is likely to expand farther inland, farther north, and higher in elevation considering climate change projections. The consequent effects of Swiss needle cast on tree foliage will likely reduce habitat quality for red tree voles.

The potential impact that this disease may have on the tree vole population is mixed. In the long term, the potential for reestablishment of Sitka spruce and western hemlock in the northwestern portion of the coast range may be beneficial by providing more of the tree species that voles in that portion of the range select for foraging and often times for nesting. However, the development of these stands into habitat may be decades off. In the meantime, stands exhibiting the disease typically are diminished in habitat quality and not likely to recover until non-host tree species develop in the stands. Furthermore, the disease is predicted to expand its range with the projected changes in climate, further modifying red tree vole habitat. We therefore conclude that the environmental effects resulting from Swiss needle cast, by itself or in combination with other factors, exacerbate threats to the North Oregon Coast DPS of the red tree vole for at least the next several decades until non-host species can recover in infected stands and they develop the older forest characteristics conducive to red tree vole habitat.

Isolation of Populations and Small Population Size

There are multiple features of red tree vole biology and life history that limit their ability to respond to habitat loss and alteration, as well as to stochastic environmental events. Due to their current restricted distribution within the DPS, stochastic events could further isolate individuals and consequently limit their recolonization capability. Small home ranges and limited dispersal distances of red tree voles, as well as their apparent reluctance to cross large openings, likely make it difficult for them to recolonize isolated habitat patches. As discussed above in the section Fragmentation and Isolation of Older Forest Habitats, forests within the DPS containing late-successional characteristics that represent high-quality habitat for red tree voles are widely separated; the average distance between the minimum patch sizes associated with nesting exceeded the known maximum dispersal distance of red tree voles. Based on this information, we conclude that high-quality older forest habitats for red tree voles within the DPS are in a highly fragmented and isolated condition.

Without the ability to move between isolated patches of occupied habitat, local populations act essentially as islands vulnerable to local extirpation, resulting from a disequilibrium between local extinction and immigration events (Brown and Kodric-Brown 1977, p. 445). Some species are adapted to living in patchy environments and may exist as a series of local populations connected by occasional movement of individuals between them, known as metapopulations (e.g., Hanski and Gilpin 1991, p. 7). However, it is presumed that the red tree vole was formerly more continuously distributed throughout the late-successional forests of the Oregon Coast Range and has only recently become insularized (i.e., isolated into islands of habitat) through habitat fragmentation. The limited dispersal ability of the red tree vole indicates this species is not adapted to living in a patchy environment where long-distance movements between populations are occasionally required. Although in many cases the tree voles within the DPS are not separated by completely inhospitable matrix habitat, but may only be isolated by surrounding areas of forest in earlier seral stages, the apparent disappearance of red tree voles from many areas where they were formerly found leads us to believe that successful recolonization of formerly occupied areas is likely infrequent, if it occurs at all (see discussion of Past and Current Range and Abundance under Factor A, above). As noted above, the average distance between patches of potentially suitable habitat at a minimum of 30 ha (75 ac) in size within the DPS exceeds the greatest known dispersal distance for a red tree vole. The apparent disappearance of red tree voles from areas where they formerly occurred, combined with the isolation of remaining habitat patches at distances on average greater than the known dispersal capability of red tree voles, leads us to conclude that movement of individuals between patches of older forest habitat is infrequent at best. Therefore, we conclude that at present, the red tree vole most likely persists as a set of relatively isolated populations in discrete patches of older forest habitat and surrounding lower quality, younger forest, with little if any interaction between these populations.

Although we do not have estimates of red tree vole population sizes within the DPS, the evidence before us suggests that remaining local tree vole populations are likely relatively small and isolated. We base this conclusion on the limited amount of tree vole habitat remaining within the DPS, on the fragmented and isolated nature of the remaining habitat, and on evidence from recent search efforts, which have yielded few voles relative to historical search efforts, suggesting that red tree vole numbers are greatly reduced in the DPS compared to historical conditions (see Background and Past and Current Range and Abundance under Factor A, above, for details). That isolated populations are more likely to decline than those that are not isolated (e.g., Davies et al. 2000, p. 1456) is discussed above. In addition to isolation, population size also plays an important role in extinction risk. Small, isolated populations place species at greater risk of local extirpation or extinction due to a variety of factors, including loss of genetic variability, inbreeding depression, demographic stochasticity, environmental stochasticity, and natural catastrophes (Franklin 1980, entire; Shaffer 1981, p. 131; Gilpin and Soulé 1986, pp. 25-33; Soulé and Simberloff 1986, pp. 28-32; Lehmkuhl and Ruggiero 1991, p. 37; Lande 1994, entire). Stochastic events that put small populations at risk of extinction include, but are not limited to, variation in birth and death rates, fluctuations in gender ratio, inbreeding depression, and random environmental disturbances such as fire, wind, and climatic shifts (e.g., Shaffer 1981, p. 131; Gilpin and Soulé 1986, p. 27; Blomqvist et al. 2010, entire). The isolation of populations and consequent loss of genetic interchange may lead to genetic deterioration, for example, that has negative impacts on the population at different timescales. In the short term, populations may suffer the deleterious consequences of inbreeding; over the long term, the loss of genetic variability diminishes the capacity of the species to evolve by adapting to changes in the environment (e.g., Franklin 1980, pp. 140-144; Soulé and Simberloff 1986, pp. 28-29; Nunney and Campbell 1993, pp. 236-237; Reed and Frankham 2003, pp. 233-234; Blomqvist et al. 2010, entire). Although we do not have any information on relative levels of genetic variability in red tree vole populations, Swingle (2005, p. 82) suggested that genetic inbreeding may be maintaining cream-colored and melanistic tree vole pelage polymorphisms at a few populations within the red tree voles range. Swingle (2005, p. 82) did not elaborate on his suggestion, nor account for the possibility that alternative processes may be maintaining these different color forms.

Based on this evaluation, we conclude that the isolation of red tree vole populations due to fragmentation of their remaining older forest habitat, independent of the total area of suitable habitat that may be left, poses a significant threat to the red tree vole within the DPS.

Summary of Isolation of Populations and Small Population Size

Remaining red tree vole populations in the North Oregon Coast DPS likely persist primarily in isolated patches of fragmented, older forest habitat, and the surrounding younger forest habitats are subject to continuing habitat modification due to timber harvest that tends to maintain the forest in this highly fragmented condition (see Factor A discussion and Fragmentation and Isolation of Older Forest Habitats, above). Red tree voles are considered highly vulnerable to local extirpations due to habitat fragmentation or loss (Huff et al. 1992, p. 1). Species that have recently become isolated through habitat fragmentation do not necessarily function as a metapopulation and, especially in the case of species with poor dispersal abilities, local populations run a high risk of extinction when extirpations outpace dispersal and immigration (Gilpin 1987, pp. 136, 138; Hanski and Gilpin 1991, p. 13; Hanski et al. 1996, p. 539; Harrison 2008, pp. 82-83; Sodhi et al. 2009, p. 518). Some conservation biologists suggest that for species with poor dispersal abilities, habitat fragmentation is likely more important than habitat area as a determinant of extinction probability (Shaffer and Sansom 1985, p. 146). The low reproductive rate and lengthy development period of young, relative to other vole species, adds further to the inherent vulnerabilities of the red tree vole and may limit population growth; the isolation of tree voles through insularization likely exacerbates these inherent vulnerabilities (Bolger et al. 1997, p. 562).

For the reasons given above, based on the observed level of habitat fragmentation and isolation that has occurred within the DPS, the presumed small size of remaining tree vole populations, and the inherent vulnerabilities of the red tree vole to local extirpation or extinction due to its life history characteristics, we conclude that the isolation of populations and the consequences of small population size pose a significant threat to the red tree vole within the North Oregon Coast DPS.

Summary of Factor E

Population isolation, presumed small local population size, and potential loss of populations to large-scale disturbance events exacerbated by climate change, combined with the life-history traits that put red tree voles at a disadvantage in moving between and recolonizing new habitats in an already fragmented landscape, are the principal threats considered under this factor that significantly affect the species. Although quantitative estimates are not available, recent surveys suggest that populations have substantially declined in the DPS, and that red tree voles are likely at greatly reduced numbers relative to their historical abundance. Furthermore, our analysis of LSOG data from the NWFP effectiveness monitoring program indicates that, within the DPS, any remaining highly suitable habitat is highly fragmented and patchy in occurrence. Patches of forest meeting older forest standards that are overly generous for red tree voles, and thus are likely overestimating the size and number of remaining patches that provide suitable habitat, indicate that the average distance between the remaining patches that are at least 30 ha (75 ac) in size exceeds the known dispersal distances of red tree voles, and the difference is even greater for patches that are more than 202 ha (500 ac) in size.

The narrow habitat requirements, low mobility, low reproductive potential, and low dispersal ability of red tree voles limits their movement among existing patches of remnant habitat, and analyses of remaining large patches of potentially suitable habitat suggests that populations of red tree voles in the DPS likely are largely isolated from one another. This information, in conjunction with evidence that the older forest habitats associated with red tree voles are highly fragmented and restricted in size, leads us to conclude that remaining populations of red tree voles are likely small in size. Furthermore, with little or no exchange of individuals between them, these small, isolated populations are at risk of local extirpation due to a variety of factors, including loss of genetic variability, inbreeding depression, demographic stochasticity, environmental stochasticity, and disturbance events. The lack of redundancy in red tree vole populations within the North Oregon Coast DPS renders these populations highly vulnerable to large-scale catastrophes or disturbance events, such as wildfire, and this vulnerability is exacerbated by climate change.

Conclusion for Factor E

Red tree voles are considered highly vulnerable to local extirpations due to habitat fragmentation or loss, and the evidence suggests that the vast majority of forest with potentially suitable characteristics for tree voles persists in very small, disconnected patches in the DPS. The continuing modification of forest habitats, as discussed under Factor A, maintains the older forest habitats associated with red tree voles in this fragmented and isolated condition. The narrow habitat requirements, low mobility, relatively low reproductive potential, and low dispersal ability of red tree voles limits their movement among existing patches of remnant habitat. This fragmentation of habitat, resulting in small, isolated populations of tree voles, can have significant negative impacts on the North Oregon Coast DPS of the red tree vole, including potential inbreeding depression, loss of genetic diversity, and vulnerability to extirpation as a consequence of various stochastic events. Although large-scale disturbance events such as fire are not common in the Coast Range, we have historical evidence of occasional very large fires in this region, and climate change projections indicate a likely increase in both fire risk and fire size. At present, red tree voles are thus largely without available refugia to sustain the population in the face of events such as severe, large-scale fires. Under these conditions, red tree voles in the North Oregon Coast DPS are unlikely to experience the habitat connectivity and redundancy needed to sustain their populations over the long term. Based on the above evaluation, we conclude that the threats of continued fragmentation and isolation of older forest habitats, as potentially exacerbated by the environmental effects of climate change and its effects on disturbance agents such as wildfire and Swiss needle cast, and the isolation of populations and consequences of small population size pose a significant threat to the red tree vole within the North Oregon Coast DPS.

We have evaluated the best available scientific and commercial data on other natural or manmade factors affecting the continued existence of the North Oregon Coast DPS of the red tree vole, including the effects of habitat fragmentation, as exacerbated by the environmental effects of climate change, isolation of small populations, and consequences of small population size, and determined that this factor poses a significant threat to the viability of the North Oregon Coast DPS of the red tree vole, when we consider this factor in concert with the other factors impacting the DPS.

Conservation Measures Planned or Implemented :

Conservation Measures

No known formal conservation agreements between the Service and other parties are in place for managing red tree voles in the north Oregon Coast DPS. Red tree voles are managed on Federal lands under NWFP guidelines as a Survey and Manage species (see Factor D, Regulatory Mechanisms on Federal Land). The ODF has identified the red tree vole as a species of concern, and has established anchor habitats for managing species of concern such as the red tree vole in portions of the DPS (see Factor D, Regulatory Mechanisms on State Land). The red tree vole is identified by the ODFW as a sensitive species in the Oregon Coast Range, and it is identified in the Oregon Conservation Strategy with specific actions believed necessary for its conservation (ODFW 2006, p. 322).

Activities that may support or inform future conservation measures

The Pacific Northwest Research Station of the U.S. Forest Service has completed a tree vole distribution, habitat, diet, and management report that is currently under review for publication. Finally, station scientists, in collaboration with Oregon State University researchers, are beginning studies on age structure of tree voles, as well as comparing detection probabilities of nests between ground surveys and climbing surveys.

Summary of Threats :

Although quantitative data are not available to estimate red tree vole populations, comparing past collection efforts with recent surveys leads us to conclude that tree voles are substantially more difficult to find now than they were historically. In some areas within the DPS, red tree voles are now not found, or are scarce, where they were formerly relatively abundant. This information, in conjunction with the knowledge that red tree voles are closely associated with older forest habitats and strong quantitative data showing an unprecedented loss of older forest habitat in the Oregon Coast Range Province, insufficient area of remaining late-successional old-growth habitat, and large distances between those remaining older forest patches that exceed known dispersal distances of tree voles, leads us to conclude that tree vole populations have substantially declined from past levels. Whereas the literature provides multiple examples of voles nesting in younger stands, virtually all analyses comparing vole nest presence or relative abundance of nests in younger versus older stands have shown an increased use or selection of older stands. Although the role of younger stands is unclear, in weighing the available evidence, including a recent modeling effort specific to habitat suitability for red tree voles, we conclude that older forests are necessary habitat for red tree voles and that younger stands will rarely substitute as habitat in the complete absence of older stands. However, we recognize that younger stands may facilitate dispersal or short-term persistence in landscapes where older forests are isolated or infrequent.

Amounts of older forest habitat within the Coast Range Province have been reduced below historical levels, primarily through timber harvest (Wimberly et al. 2000, p. 176). The occurrence of forest structural conditions outside of the historical range of variability may not in itself be a problem with respect to red tree vole persistence, considering their persistence through historical large-scale fires that removed habitat. However, the frequency and duration of those conditions outside the historical range of variability will ultimately affect the persistence of the red tree vole.

Historically, old-growth forest (greater than 200 years old) was well dispersed (Wimberly et al. 2004, p. 152) within the Oregon Coast Province and there were large tracts of suitable habitat that served as refugia in which tree voles could persist while adjacent disturbed areas grew into habitat (Wimberly et al. 2000, p. 177). Such areas likely served as source areas to recolonize newly developed habitats (Pulliam 1988, pp. 658-660; Dias 1996, p. 326). However, if the amount or duration of unsuitable habitat exceeds the ability of the species to persist in refugia and ultimately recolonize available areas, the species may eventually be extirpated. Hence, the longer habitat stays in an unsuitable condition, the greater the risk to the population (Wimberly et al. 2000, p. 177).

Under current management conditions, the vast majority of remaining red tree vole habitat in the DPS is, and will continue to be, limited to Federal lands. Federal lands make up less than a quarter of the area within the DPS, and are limited to two disparate clusters of land. Although 62 percent of the Federal ownership in the DPS is currently managed under the NWFP to develop and maintain late-successional conditions that would be conducive to red tree vole habitat, only 30 percent of these Federal lands are currently estimated to provide suitable habitat for red tree voles (Dunk 2009, pp. 5, 7). Even if the entire Federal ownership provided older forest habitat conducive to red tree vole occupation, this would still represent a significant reduction of older forest habitat based on estimates from simulations of forest conditions in the Coast Range Province during the past 3,000 years (Wimberly et al. 2000, pp. 173-175; Nonaka and Spies 2005, p. 1740). Although much of this loss was historical, it led to the present condition of insufficient habitat for red tree voles today; at present, less than 1 percent of the habitat within the DPS is in the condition for which red tree voles showed the greatest strength of selection for nesting, and nearly 90 percent of the DPS is in a condition avoided by red tree voles. Most of the lands in the nearly 80 percent of the DPS under State and private ownership are managed for timber production. Although regulatory mechanisms exist that are intended to provide for the conservation of wildlife and habitats during the course of timber harvest activities on private and State lands, the habitat requirements and life-history characteristics of the red tree vole are such that these regulatory mechanisms are inadequate to prevent the ongoing modification, fragmentation, and isolation of red tree vole habitat on these lands.

Our own analysis of NWFP data demonstrates the fragmentation and isolation of large patches of older forest remain within the DPS. Fifty-nine percent of the LSOG within the DPS comprised patches greater than 30 ha (75 ac), the minimum stand size in which tree voles are found, and the average distance between these patches exceeds the known dispersal limits of tree voles (USFWS 2010, unpublished data). Furthermore, the criteria used to define the initial dataset of late-successional forest used in our analysis includes forest conditions that are not suitable for red tree voles (e.g., low canopy cover, predominant hardwood cover), so these results are overestimates of habitat remaining for red tree voles. Finally, applying the proportion of large patches within the DPS onto the amount of tree vole habitat estimated within the DPS (Dunk 2009, p. 7) indicates only about 6 percent of the DPS is in a condition of suitable habitat in patches large enough to provide for tree voles, and this analysis is considered a likely overestimate of tree vole habitat. Clearly, existing and projected amounts of older conifer forest habitat conducive to red tree vole persistence are less than the amounts projected to have occurred historically and with which tree voles have evolved. High-quality older forest habitat remains in isolated fragments, most of which are too small to support tree voles, and are so widely separated as to likely be well beyond the dispersal capability of the species. Unlike historical conditions, which were highly stochastic, these changes are likely to be permanent. Based on our analysis of best available information, we conclude the remaining high-quality habitat within the DPS is likely insufficient to support red tree voles over the long term, and persists in a fragmented and isolated condition that renders local populations of red tree voles vulnerable to extirpation or extinction through a variety of processes, including genetic stochasticity, demographic stochasticity, environmental stochasticity, and natural catastrophes.

The significant historical losses of older forest with the late-successional characteristics selected by red tree voles, in conjunction with ongoing practices that maintain the remaining patches of older forest in a highly fragmented and isolated condition by managing the surrounding younger forest stands on short-rotation schedules, pose a threat to the persistence of the North Oregon Coast DPS of the red tree vole through the destruction, modification, or curtailment of its habitat or range.

Furthermore, barring a significant change in the Oregon Forest Practices Rules and Act, loss, modification, and fragmentation of red tree vole habitat is likely to continue on most of the 62 percent of the DPS that is privately owned. Forecasts for State forest land, which makes up almost all of the 16 percent of the DPS in State ownership, are to manage 15 to 25 percent of their land in older forest structure, with another 15 to 25 percent to be managed as layered forest structure. However, it is expected to take 70 years before reaching these amounts, with only 8 percent of the State lands currently existing in these structural conditions. Active management via thinning to reach these targeted structures, while potentially developing suitable tree vole habitat in the long term, may further limit the potential for well-connected tree vole populations in the ensuing 70 years. Current regulations on private and State lands provide for timber harvest on relatively short rotation schedules; this contributes to the modification of older forest habitat, and maintains forest in a low-quality condition for red tree voles. Although some incidental benefits may accrue to individual red tree voles from the buffers put in place to protect habitat and targeted wildlife species under the Forest Practices Rules, in general the patches of forest remaining under these guidelines are too small and isolated to provide for the persistence of red tree voles. In some harvest units, the regulations require the retention of only five trees per ha (two trees per ac), and the size of these trees is well below that normally used by red tree voles. The linear perpendicular extent of tree retention along fishbearing streams under the State regulations is dramatically less (about one-fifteenth) than that conserved under Federal regulations. The scarcity of red tree voles throughout much of the DPS where they were formerly found with ease further suggests the forest areas retained under the existing regulatory mechanisms are insufficient to support persistent tree vole populations or successful dispersal and recolonization. Finally, unlike on Federal lands, there are no mechanisms in place on private or State lands to survey for tree voles and manage for sites that are located. We have therefore found existing regulatory mechanisms on private and State lands inadequate to provide for the conservation of the red tree vole within the DPS.

The current presumed limited population size and distribution of the red tree vole within a small portion of the DPS makes the species particularly vulnerable to random environmental disturbances such as fires. Evidence from past fire events indicates that stand replacement fires have historically occurred in this area large enough that, if fires of similar size were to occur now or in the foreseeable future, could eliminate most, if not all, of the largest patches of remaining high-quality older forest habitat in the DPS. This is of particular concern because the stronghold of the red tree vole population in this DPS is likely concentrated in a single cluster of Federal lands south of Highway 20, and the potential loss of the high quality habitat on these lands to an event such as a fire would remove the greatest source population of red tree voles in the DPS. Other populations are more fragmented and isolated and have little potential to contribute to the overall persistence of the DPS under current conditions of habitat fragmentation. Population connectivity is thus a particular concern given the species reduced numbers, habitat specialization and limited dispersal capabilities, combined with the limited distribution of older forests located primarily on Federal land within the range of the red tree vole (USDA and USDI 2000a, p. 186). Even on the cluster of Federal lands north of Highway 20, remaining habitat has been deemed insufficient to support stable populations of red tree voles (USDA and USDI 2007, pp. 291-292).

Finally, though the precise effects of environmental changes resulting from climate change on red tree vole habitat are unknown, the projected increase in size and severity of forest disturbance vectors such as fire and pathogens are expected to further reduce and isolate habitat and tree vole populations. In addition, projected shifts in the range of species to the north and to increased elevations would further reduce the available habitat for the red tree vole, given that it is already at its northern and elevational limit within the North Oregon Coast DPS. Therefore, we have additionally found that the North Oregon Coast DPS of the red tree vole is threatened by the exacerbating effects of other natural or manmade factors affecting its continued existence.

Given the threats described above, we find that the North Oregon Coast DPS of the red tree vole is in danger of extinction now or in the foreseeable future and therefore warrants listing. We have considered time spans of several projections of forest conditions and associated tree vole response and other measures of biodiversity to determine how far into the future is reasonably foreseeable. Trends in timber harvest and biodiversity in the Oregon Coast Range are projected for the next century (Johnson et al. 2007, entire; Spies et al. 2007a, b, entire). Although older forest structure is expected to develop on some areas of State land and in those Federal land allocations managed for late-successional conditions, existing stands are in a variety of age and structural stages and it will be several decades before those stands develop older forest structure and late-successional conditions. For example, on State lands, it is estimated that it will take at least 70 years to develop the targeted amounts of forest complexity (ODF 2010b, p. I-13). Congruent with the time spans stated above, we have determined the foreseeable future for the red tree vole to be approximately 70 to 100 years.

In summary, several threats, combined with the limited ability of the red tree vole to respond to those threats, contribute to our finding that the North Oregon Coast DPS of the red tree vole is in danger of extinction now or in the foreseeable future. Older forest habitats that provide for red tree voles are limited and highly fragmented, while ongoing forest practices in much of the DPS maintain the remaining patches of older forest in a highly fragmented and isolated condition by managing the surrounding younger forest stands on short-rotation schedules. Existing regulatory mechanisms on private and State lands result in the maintenance of this condition on most of their ownership. Although a portion of the State forest land will be managed towards older forest structure, it is expected to take 70 years before reaching these conditions. Red tree vole populations within the North Oregon Coast DPS appear to be relatively small and isolated. Multiple features of red tree vole biology and life history limit their ability to respond to the above noted habitat loss and alteration. These features include small home ranges, limited dispersal distances, low reproductive potential relative to other closely related rodents, a reluctance to cross large openings, and likely increased exposure to predation in certain habitat conditions (e.g., younger stands or in areas with insufficient canopy cover that forces voles to leave trees and travel on the ground). Such life history characteristics make it difficult for red tree voles to persist in or recolonize already isolated habitat patches. Although some land management allocations within the DPS call for developing older forest conditions that may provide habitat for the red tree vole, it will be decades before those areas attain those conditions. In the interim, the red tree vole remains vulnerable to random environmental disturbances that may remove or further isolate large blocks of already limited habitat (e.g., large wind storms or stand-replacing fire events). Finally, small and isolated populations such as the red tree vole are more vulnerable to extirpation within the DPS due to a variety of factors including loss of genetic variability, inbreeding depression, and demographic stochasticity. Because of the existing habitat conditions, the limited ability of the red tree vole to persist in much of the DPS, and its vulnerability in the foreseeable future until habitat conditions improve, we find that the North Oregon Coast DPS of the red tree vole is in danger of extinction now or in the foreseeable future.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Service to work with Federal, State, private, and research partners to strategize how landowners are best able to contribute to conservation needs of the species; prioritize research needs that may inform possible conservation strategies.

Information needs

Improve our understanding about the ability of tree voles to persist in younger forest stands:

1. How long can they persist in younger forest stands?
2. What are the factors that limit their persistence?
3. What is the ultimate fate of tree vole individuals in these stands (e.g., do they die or emigrate?)

Monitor tree vole response to silvicultural treatments in nest stands, particularly silvicultural treatments (e.g., variable spacing thinning, and patch cuts) designed to accelerate development of late-successional conditions.

Determine the effectiveness of the 4-ha (10-ac) buffers in maintaining tree vole occupancy over the long term. (The 4-ha (10-ac) buffer is the protection guideline in place under the Survey and Manage program on Federal lands for active vole nests found in project areas).

Assess habitat and population connectivity in the DPS. Consider additional genetic research that may refine the DPS boundary. Quantify tree vole habitat within the DPS and assess the degree to which it is occupied.

Conduct research and fill information gaps including the following:

- Are populations isolated and are there habitat management alternatives that could improve population connectivity? Do a fragmentation/connectivity analysis on existing habitat to determine what areas are isolated and where treatments to develop habitat may be most prudent to apply.
- What is the population status and trend of the species?
- To what degree does the presence of trees severely afflicted with Swiss needle cast affect red tree vole survival and persistence?

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	**Imminent**	Monotypic genus	7
		Species	8
		Subspecies/Population	**9**
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

We consider the threat magnitude moderate because, although the entire population is experiencing threats, the impact of those threats is more pronounced on private and State ownerships than on Federal lands, where more of the existing tree vole habitat is likely to remain. For example, our analysis indicates that remaining forested habitat on Federal lands provides a measure of security to extant vole populations. Although timber harvest across the DPS is a concern, the loss of suitable vole habitat to timber harvest has declined, and the current status of the species may reflect a lag effect from previous timber harvest. At the same time, much of the Federal forested lands are growing toward older conditions and management of these lands is targeted toward increasing the older forest condition of the landscape. In consideration of all these factors, we find the magnitude of threats to be moderate to low.

Imminence :

We consider the threats imminent because they are currently occurring within the DPS.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

We have determined that issuing an emergency regulation temporarily listing the species is not warranted for the North Oregon Coast DPS of the red tree vole at this time. While the red tree vole faces multiple threats within the north Oregon Coast DPS, none of the threats are of a magnitude and severity that warrants emergency listing (see description of magnitude above). Voles are currently distributed across multiple areas within the DPS and we do not believe there are any potential threats of such great immediacy, severity, or scope that would simultaneously threaten all of the known populations with the immediate risk of extinction.

Description of Monitoring:

On March 10, 2015 the Service sent an email to the following known red tree vole researchers asking for an update on status of new or ongoing research on red tree voles in the past year:

1. Dr. Eric Forsman (retired), U.S. Forest Service, Pacific Northwest Research Station, Corvallis, Oregon (via Jim Swingle)
2. Dr. Mark Miller, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon
3. Dr. Daniel Rosenberg, Oregon State University, Corvallis, Oregon
4. Jim Swingle, Oregon State University, Corvallis, Oregon

On March 10, 2015 the Service sent an email to the sensitive and special status species coordinators for both the BLM (Rob Huff, Oregon State Office) and Forest Service (Carol Hughes, Pacific Northwest Region 6) requesting information on any changes in Federal land management or protection status for red tree voles that may have occurred during the past year.

The Service also conducted a literature search late February, 2014, looking for articles published in 2013 or 2014 that contained the phrases "red tree vole," Arborimus longicaudus, Phenacomys longicaudus, and Phenacomys silvicola.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Oregon

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

The Service sent emails on March 10, 2015, to the Oregon Department of Fish and Wildlife (Martin Nugent) and the Oregon Department of Forestry (Nick Palazzotto), respectively, wherein we requested:

1. Information about changes in management of the species, and new information specific to the DPS that may have arisen during the past year.
2. Information on any conservation agreements that the state may be entering into or exiting from that may affect red tree vole management (even if the agreement is not explicitly for red tree voles).
3. Information on any survey efforts the state may be doing for red tree voles.

The Oregon Department of Forestry provided new information updating the area of State Forests protected by Anchor Habitats and by buffers for marbled murrelets and northern spotted owls.

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Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: 06/23/2015
Date

Concur: 12/15/2015
Date

Did not concur: ______________________ ________
Date

Director's Remarks: